7221-1

instruction manual

INSTRUCTION MANUAL

MODEL 7370R

UNIVERSAL EPUT® & TIMER

Beckman®

Berkeley Division

INSTRUCTION MANUAL

MODEL 7370R
UNIVERSAL EPUT® & TIMER

Serial 2179

NOTE

If model number is followed by one or more letters, the instrument covered by this manual has been modified. See section on modifications.

Beckman

Berkeley Division
2200 Wright Avenue, Richmond 3, California
a division of Beckman Instruments, Inc.

1960

WARRANTY

Instruments sold by Berkeley Division, Beckman Instruments, Inc., (hereafter called "the Company") are warranted only as stated below.

Subject to the exceptions and upon the conditions specified below, the Company agrees to correct, either by repair, or, at its election, by replacement, any defect of material or workmanship which develops within one year after delivery of the instrument to the original purchaser by the Company or by an authorized representative, provided that investigation and factory inspection by the Company discloses that such defect developed under normal and proper use.

The exceptions and conditions mentioned above are the following:

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(g) This warranty shall be governed by the laws of the State of California.

Claims for damage in shipment should be filed promptly with the transportation company.

All correspondence concerning the instrument should specify the model and serial number. This information appears on the company name plate. Any inquiry concerning details of operation, possible modifications, etc., should be addressed to the Sales Department, Berkeley division of Beckman Instruments, Inc., Richmond 4, California.

REPAIR SERVICE

Experienced service personnel and special test equipment are available at the factory to perform any necessary repairs. Every effort will be made to expedite the repair of instruments returned for servicing. Repair work will be performed only upon receipt of a written purchase order or authorization. Instruments to be repaired should be addressed to SERVICE AND REPAIR DEPARTMENT with transportation charges prepaid. Repaired instruments will be returned to the purchaser with transportation charges collect.

Berkeley reserves the right to make changes in design at any time without incurring any obligation to modify equipment previously purchased to conform to subsequent design changes.

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DRAWINGS

Model 7370 Block Diagram
Master Schematic Diagram, Dwg. No. 7370 D 200
E Input Channel, Schematic Diagram, Dwg. No. 7370 C 700
A or B Input Channel, Schematic Diagram, Dwg. No. 7370 C 300
Oscillator & Multiplier, Schematic Diagram, Dwg. No. 7370 D 421
Frequency Divider, Schematic Diagram, Dwg. No. 7370 D 620
Power Supply, Schematic Diagram, Dwg. No. 7370 C 100

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INTRODUCTION

1.1 GENERAL DESCRIPTION

The Universal EPUT® and Timer is an electronic counter which will perform a wide variety of frequency and time measurements. These various functions are described below under "SPECIFICATIONS". The instrument consists of a precision time base generator, three input pulse-forming (trigger) channels, an electronic gate and a chain of decimal counting units. When measuring frequency, each cycle of the input signal causes an input channel to emit a sharp voltage pulse. These pulses pass through the gate and are counted by the decimal counting units during the precise time interval separating successive clock pulses from the time base generator. When measuring time, clock pulses are let through the gate and counted during an interval controlled by input signals.

The instrument will count at a maximum rate somewhat above 10 million events-per-second, making it possible to measure frequencies as high as 10Mcs reliably. The count indication consists of seven illuminated digits on the front panel. The operator can adjust the instrument to retain this display indefinitely, or he can adjust it to hold the display for from .05 to 5 seconds, then reset to zero automatically and begin another counting period.

The basic time reference is a crystal-controlled one Mcs oscillator within the instrument. This oscillator has a maximum frequency drift of 3 parts in 10^7 per week. An external 1Mcs signal may be substituted for the oscillator signal if the operator so desires.

The instrument can be tested for proper operation in a fraction of a minute simply by manipulating front-panel controls and observing the count indication. This test checks all frequency dividers, multipliers and decimal counting units.

1.2 SUMMARY OF FUNCTIONS AND SPECIFICATIONS

1.2.1 FREQUENCY MEASUREMENTS. The instrument will count the number of events which occur during a precise time interval. Since each cycle of the input signal represents one event, this measures the frequency of the input signal.

Frequency Range

10cps to 11.5Mcs.

Counting Period

Selectable in decade steps from 1μsecond to 10 seconds with a manual extension beyond 10 seconds.

Accuracy

± one count ± crystal accuracy.

Input Requirements and Adjustments Available

See section 1.2.6.

1.2.2 PERIOD MEASUREMENTS. The instrument will time the interval between two events represented by successive voltage excursions at the same input jack. If successive voltage excursions have the same polarity, this is a period measurement. If successive excursions have opposite polarity, it becomes a pulse width measurement. The instrument will also time the interval between every tenth input excursion, thus measuring ten periods.

Input Frequency Range

D-C to 3Mcs.

Units in which Time Measurement Appears

Selectable in decade steps from tenths of a microsecond to seconds.

Maximum Measurable Interval

10,000,000 time units

Accuracy

Depends partly upon amount of noise on input signal. With noiseless signal, accuracy is ± one time unit ± oscillator accuracy.

Input Requirements and Adjustments Available

See section 1.2.7.

1.2.3 TIME INTERVAL MEASUREMENTS. The instrument will time between two events, each represented by a voltage excursion at a separate input jack. When a signal is applied to one input jack and the same signal in a different phase to another input jack, the result of this measurement is the phase difference. The units in which the time measurement appears, the maximum measurable interval and the accuracy are the same as in the case of period measurements. See section 1.2.7 for input requirements and the input adjustments available.

1.2.4 The instrument will count the number of events occurring between two other events. The two events which start and stop the counting action may be represented by signals at the same or separate input jacks. See section 1.2.6 for input requirements of signal representing events to be counted. See section 1.2.7 for requirements of signal which start and stop the counting action.

1.2.5 The instrument will count the number of events occurring during a manually-controlled time interval. See section 1.2.6 for input requirements.

1.2.6 "E" INPUT TRIGGER CHANNEL

Function

Every cycle of signal applied to this channel is counted during counting operations. Not used during timing operations.

Input Frequency Range

10 cps to 11.5Mcs.

Input Coupling

A-C.

Input Sensitivity

0.3 volts peak-to-peak (0.1v rms).

Input Attenuation

Attenuation control is provided to attenuate input voltage by a factor of 10 or 100, thus decreasing sensitivity to 3v or 30v peak-to-peak respectively.

Trigger Slope

Channel triggers on negative-going part of input waveform.

Input Impedance

One megohm in parallel with 40$\mu\mu$f.

Maximum Permissible Input Voltage

400 volts peak-to-ground.

1.2.7 "A" and "B" INPUT TRIGGER CHANNELS

Function

A channel: During operations in which this channel is used, the input voltage excursion stops the counting action.

B channel: During operations in which this channel is used, input voltage excursions either start the counting action or both start and stop the counting action.

Input Frequency Range

D-C to 3Mcs.

Input Coupling

Choice of a-c or d-c.

Input Sensitivity

0.6 volts peak-to-peak (0.2v rms). With a-c coupling the sensitivity begins to decline appreciably when the frequency falls below 5 cps.

Input Attenuation

Attenuation control is provided to attenuate input voltage by a factor of 10 or 100, thus decreasing sensitivity to 6v and 60v peak-to-peak respectively.

Trigger Voltage Level

Channel triggers when input signal (after attenuation) passes through a certain instantaneous voltage level. This level can be varied continuously from -1v to + 1v.

Trigger Slope

Channel will trigger on either a positive-going or a negative-going input voltage excursion.

Input Impedance

D-C coupled: One megohm in parallel with 40$\mu\mu$f

A-C coupled: One megohm in parallel with 40$\mu\mu$f and in series with .01μf

Maximum Permissible Input Voltage

500 volts peak-to-ground

1.2.8 TIME BASE GENERATOR

Output Frequency

Selectable in decade steps from 10 megacycles to 10 cps.

Output Clock Pulses (available for external use)

Pulse Height: +5 volts

Pulse Width: 1/10 of pulse interval (0.5μseconds at 1 MC)

Output Impedance: 300 ohms.

Pulse Interval: 1 μsecond to 1 second selectable in decade steps.

Oscillator Stability

3 parts in 10^7 per week.

1.2.9 CONTROL CIRCUITS AND INDICATORS

Resolution

Gating: 0.3 μsec.

Counting: 0.1 μsec.

Count Capacity

7 digits

Count Display

Display time is continuously variable from .05 to 5 seconds.

Coded Readout

A 4-line modified binary code, representing each digit displayed, is available at a rear-panel connector.

1.3 APPLICATIONS

The Universal EPUT and Timer can be used to make a wide variety of frequency and time measurements both in the laboratory and on the production line. It is useful in designing transmitters, receivers, tuned circuits, crystals, oscillators and other equipment which must have definite frequency characteristics. On the production line the instrument is ideal for making stability checks on transmitting and receiving equipment and on crystals during heat cycling. It may also be used to calibrate less accurate frequency monitoring equipment.

Various transducers such as photocells, magnetic pickups and switches may be used to produce voltage changes representing physical events. So equipped, the instrument will measure the characteristics of such events relative to time. Some of the known applications of the instrument are:

Frequency measurements
Frequency ratio measurements
Relay and switch timing
Phase measurements
Viscosity and ballistic measurements
Elasticity measurements
Tachometry
Telemetery
Pulse height analysis
Oscilloscope time base calibration
Use as a secondary frequency standard

1.4 ACCESSORIES

The versatility of the instrument can be fully utilized only when it is equipped with the proper accessories. Numerous transducers such as the Model 441 Reflecting Tachometer as well as several data recording and data reduction instruments are available at Berkeley. The Model 1452 Digital Recorder, designed for use with this instrument, converts count information into a printed record. The unit prints the count accumulated by the counter during each counting period. The printed count appears sequentially in Arabic numerals on a standard adding machine tape. This recorder is ideal for making long term stability checks, recording transients, monitoring, or for making a permanent printed record in control or measuring systems.

Beckman/Berkeley Data Reduction Converters convert the digital readout information from the counter to a form suitable for actuating an IBM summary punch or an electric typewriter. A modification of this equipment can be made, on special order, which will drive a teletype or a microwave link. In this way, count information may be made instantaneously available at remote locations.

A Berkeley Digital to Analog Converter converts the count accumulated during each counting period to a representative voltage level. This voltage is held until a new count is completed when it changes to conform with the new count. The unit may be used with a self-balancing potentiometer to provide an analog record, or the changing voltage level may be used to control the operation being monitored.

Other converters, transducers and special equipment may be ordered to meet specific problems.

2.1 TYPES OF MEASUREMENT POSSIBLE

The counter will make three types of measurements in addition to manually-gated counting.

1. It will count the number of events occurring during a precise time interval. This is known as Events-Per-Unit-Time or E/UT operation. Frequency measurements are made in this way. The SCAN function is a variation of this operation.
2. It will measure the time interval between two events. If the two events are represented by voltage changes on separate input channels, it is called Time-Interval-Measurement or TIM operation. If the two events are represented on the same input channel, this is known as PERIOD operation.
3. It will count the number of events occurring between two other events. This is E/B or E/B-A operation.

If the events mentioned above are not initially voltage changes, appropriate transducers are used to produce voltage changes representing the events at the counter inputs. Three input trigger channels within the counter convert the voltage changes they receive into sharp pulses. A Time-base generator in the instrument produces similar pulses separated by a precise time interval. Besides these four pulse sources, the counter contains an electronic gate and a chain of seven decimal counting units (DCU's). The DCU's count and indicate the number of pulses which pass through the gate between a start pulse which opens it and a stop pulse which closes it.

The FUNCTION switch determines the type of measurement made by selecting the pulse source which provides each of the three signals -- pulses to be counted, the start pulse and the stop pulse.

1. Under E/UT Operation, the E input channel provides pulses which are counted over the known time interval between start and stop pulses selected from the time-base generator.
2. Under PERIOD or TIM Operation, clock pulses of known frequency from the time-base generator are counted over an unknown interval between start and stop pulses from the same or separate input channels. Since the clock-pulse frequency is equal to the 1 MC oscillator output frequency divided or multiplied by a power of 10, the time measurement appears directly in decimal fractions of a second.
3. Under E/B Operation, pulses from one of the input channels are counted between start and stop pulses from the other channel. If the events represented by the pulses are cycles of input signal waves, the DCU's indicate the number of cycles at one input which occur during one cycle at the other input or, in other words, a frequency ratio. Under E/B-A Operation, pulses from one channel are counted between a start pulse from another channel and a stop pulse from a third channel.

During all "times ten" (X10) operations, the start-stop pulse frequency is divided by 10 so that the counting period is multiplied by 10 and the reading is 10 times as large. The maximum count indication in this type of operation, and in SCAN operation, is six digits since the seventh DCU is used as a frequency divider unit. Figures 3b through 12b show the selection of pulse sources for each type of operation.

2.2 INSTALLING AND APPLYING POWER

The instrument is ready for use as it arrives from the factory. For proper cooling, it must be operated inside the cabinet. The unit can be taken out of its cabinet, and mounted in a standard 19 inch rack if a dust cover (available on order) is first installed over the top of the chassis. For chassis dimensions see MODIFICATION R in section on modifications.

The oscillator crystal oven in the instrument becomes energized as soon as the power cord is connected to a 117 v AC outlet. Starting cold, the oven will bring the crystal to the correct stable temperature within one hour. Only then will the instrument perform with maximum accuracy. Therefore, if the instrument is to be used intermittently, leave the power cord connected at all times to avoid waiting while the crystal warms. The power consumed by the crystal oven is negligible, and no other circuitry is energized.

To energize the remaining circuitry, turn the POWER switch on. The green indicator light will glow and, after a warm-up of about two minutes, the instrument will be ready for use.

NOTE: The life of the crystal oven assembly can be increased by rewiring the heater element to the other side of the POWER switch as shown in Figure 1. (See Oscillator schematic diagram for pin numbers.) When this is done, it takes about 5 to 8 minutes of warm-up time to reach a stability of one part in 10^6. It takes about 15 to 20 minutes for a stability of one part in 10^7.

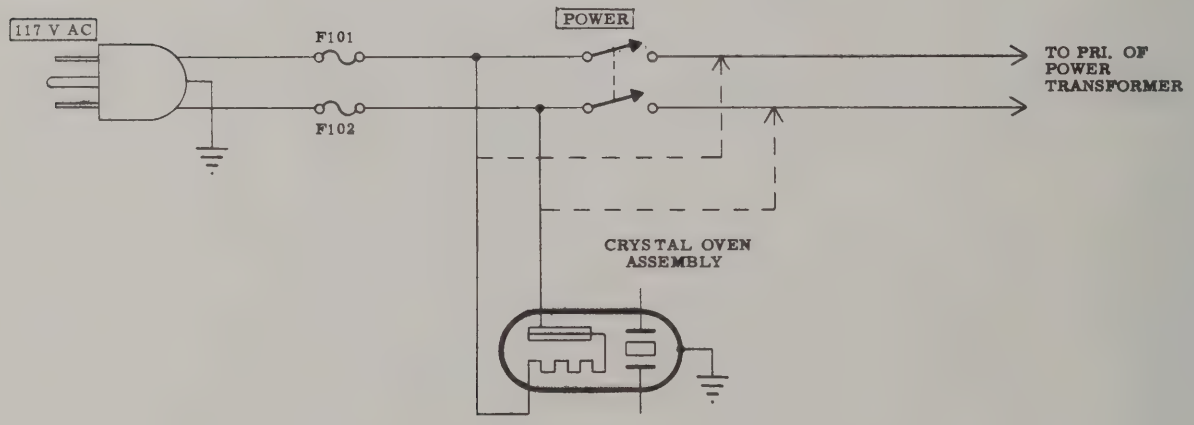


FIGURE 1 REWIRING OF OSCILLATOR CRYSTAL OVEN

FIGURE 2a. FRONT PANEL VIEW OF THE MODEL 7370

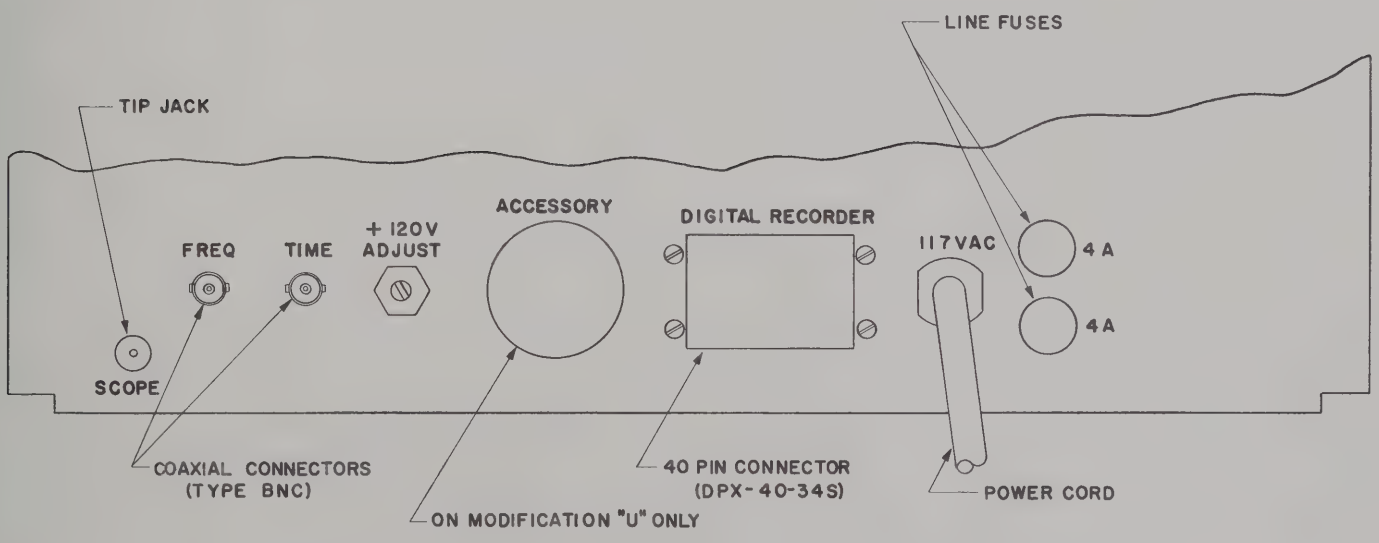


FIGURE 2b. RELATIVE LOCATION OF REAR PANEL CONNECTORS

2.3 OPERATING CONTROLS AND CONNECTORS

POWER switch

Turns power on and off.

FUNCTION switch

1. Interconnects major components to perform the measurement indicated by the pointer.
2. Used to manually control SCAN operation.

TIME-SECONDS switch

Selects time interval for events-per-unit-time and TEST measurements and units in which time measurement appears for PERIOD and TIM B-A measurements.

ATTENUATION controls

Attenuates the signal at the adjacent INPUT jack by the voltage factor to which the pointer is set. When turned to the AC side only the a-c component of the input signal reaches the input trigger channel.

TRIGGER VOLTAGE controls

Selects the instantaneous voltage level at which the attenuated signal triggers the adjacent input channel.

SLOPE switches

Selects the slope of the input voltage waveform which triggers the input channel pulse used to operate the gate and control circuitry. The input channel which each SLOPE switch affects varies with the position of the FUNCTION switch. See instructions for selected mode of operation to determine the function of the SLOPE switches at a particular position of the FUNCTION switch.

DISPLAY Time Control

Determines how long the instrument holds a reading before resetting and beginning another count. When this control is turned to the extreme clockwise position, the instrument will hold a reading until the manual RESET button is depressed.

Manual RESET Button

Removes the previous reading and readies the instrument to begin another counting period.

INPUT Jacks

For signal inputs to the three input trigger channels.

NOTE

See "Auxiliary Connectors", section 2.9, for information on connectors used in special variations of the standard operating procedures.

2.4 TESTING FOR PROPER OPERATION

The self-checking procedure is simple and quick. It should be performed each time the instrument is newly energized and has had time to warm up. The operator may also wish to test the instrument at intervals throughout the day in order to reassure himself that the equipment is operating properly.

1. Turn DISPLAY Time to a point near the extreme counter-clockwise position to obtain a short display time and automatic operation.
2. Turn FUNCTION switch to TEST.
3. Rotate TIME switch to each position starting with 10^{-6}. The following count indications should appear:

TIME switch Position	Correct Count Indications
10^{-6}	0000009 or 0000010 or 0000011
10^{-5}	0000099 or 0000100 or 0000101
10^{-4}	0000999 or 0001000 or 0001001
10^{-3}	0009999 or 0010000 or 0010001
10^{-2}	0099999 or 0100000 or 0100001
10^{-1}	0999999 or 1000000 or 1000001
1	9999999 or 0000000 or 0000001

4. If a correct count indication appears at all positions, the instrument is operating properly. If the registered count is incorrect in all TIME switch positions by a factor of 1/5 (for example, 80 instead of 100) the 1 Mcs to 10 Mcs multiplier is probably incorrectly adjusted. If the registered count is incorrect in some of the TIME switch positions by a factor of 1/10, one of the Frequency Divider adjustments is probably incorrect. Refer to "Servicing" for directions on adjusting the multiplier and dividers.

2.5 MODES OF OPERATION

2.5.1 General Procedure for Making Measurements

First, decide which mode of operation will accomplish the desired object. There are several different modes of operation, each corresponding to a position of the FUNCTION switch. Each mode is treated separately on the pages which follow. Sometimes the same object may be accomplished by more than one mode of operation. In these cases, one mode will be preferable to the others. For example, the frequency of a stable a-c signal can be measured either directly under E/UT or E/UT x 10 Operation, or indirectly by measuring the period of the signal and calculating the frequency (PER B Operation). The direct method is simpler and will ordinarily be used except when measuring a low frequency signal with extreme accuracy.

Second, follow the operating procedure given on the same page where the mode of operation is described. These instructions will occasionally refer you to other parts of the manual for directions.

2.5.2 E/UT (Event-Per-Unit Time) Operation

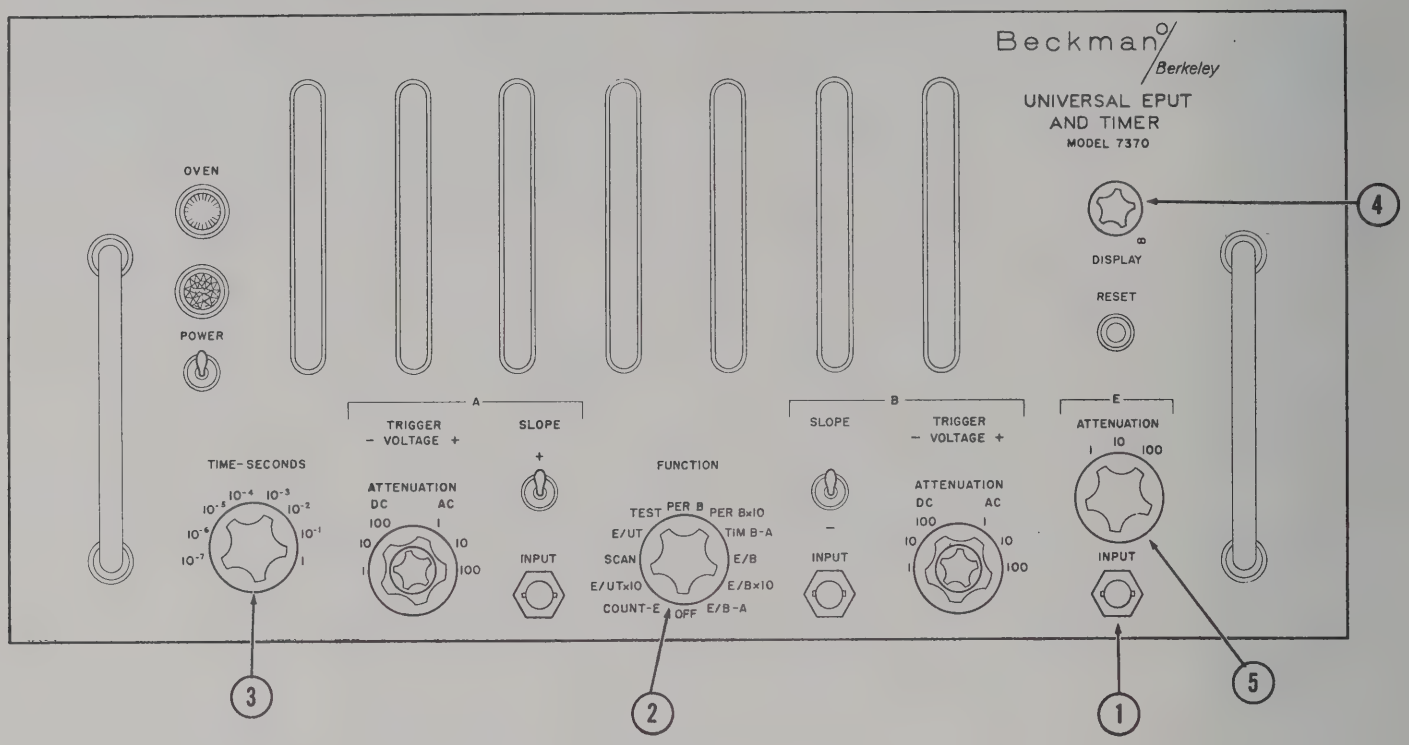


FIGURE 3a

What Kind of Measurement is Made. At the E/UT position of the FUNCTION switch the unit counts cycles of the signal at the E INPUT between start and stop signals separated by a precise time interval. This setting may be used to measure the frequency of a signal or the number of events occurring within a selected time interval. The major components are connected as diagrammed in figure 3b.

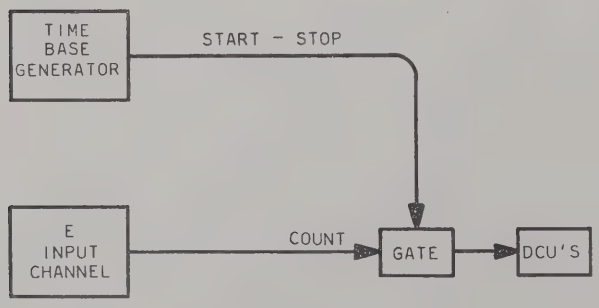


FIGURE 3b

Operating Procedure. To make a measurement, proceed as follows:

1. Connect the input signal to the E INPUT jack. Input requirements appear in section 2.6.
2. Rotate the FUNCTION switch to the E/UT position.
3. Set the TIME switch at the time interval over which events are to be counted.
4. Adjust the DISPLAY time control to a position at which the count indicated by the lighted numerals may be read conveniently.
5. Adjust the ATTENUATION control as described in section 2.6.
6. To obtain a measurement in events per second, divide the reading on the lighted numerals by the number to which the TIME switch is set. For example, if the reading is 150 and the TIME switch is set at 10^{-3} the rate will be 150 divided by 10^{-3} which equals 150,000 events per second.

2.5.3 E/UTx10 Operation

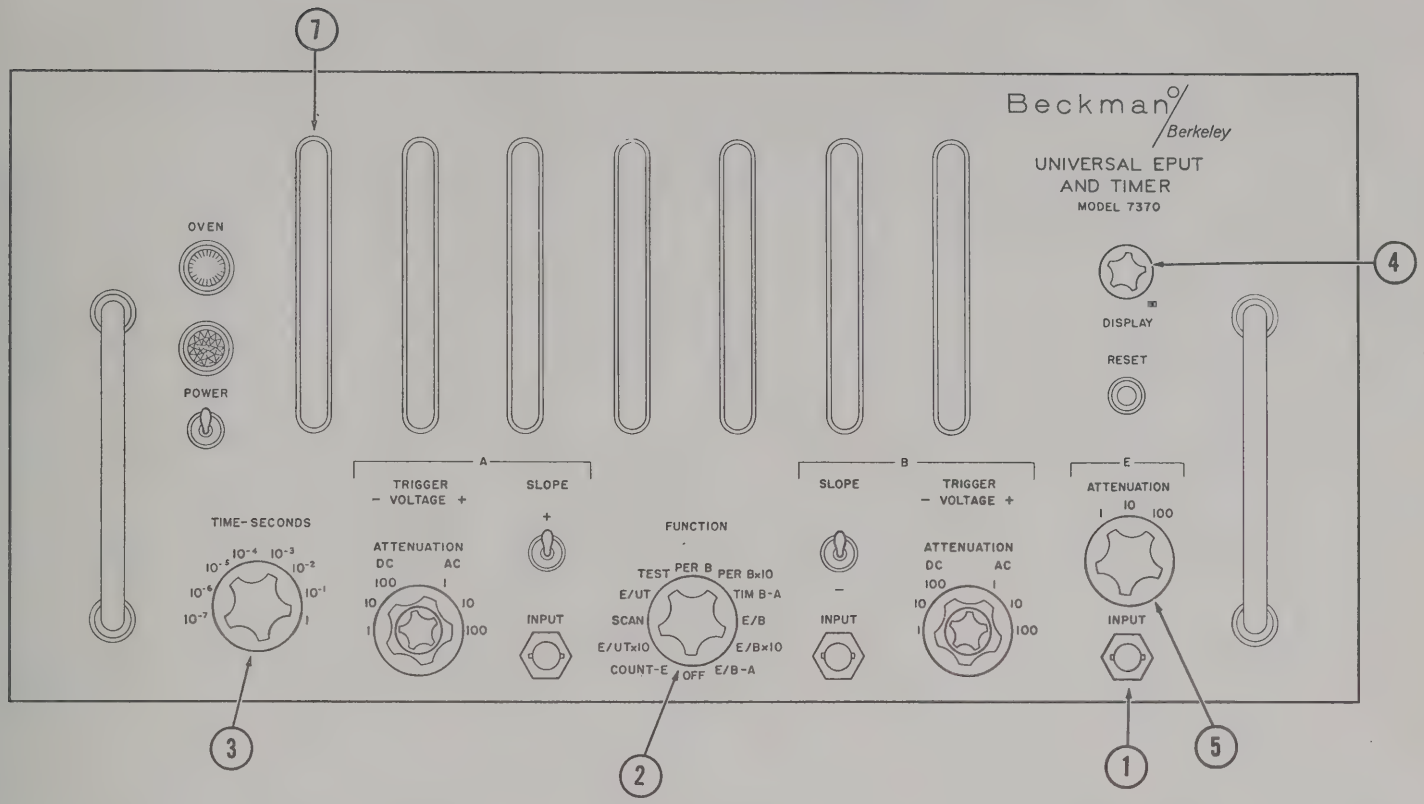


FIGURE 4a

What Kind of Measurement is Made. At the E/UT x 10 position of the FUNCTION switch the unit counts every cycle of the signal at the E INPUT between stop and start signals separated by 10 times the interval indicated by the TIME switch. Counting over the 10-second period produces more accurate frequency measurements than can be made using shorter time intervals. The major components are connected as diagrammed in figure 4b.

Operating Procedure. To make a measurement, proceed as follows:

(1) Connect the input signal to the E INPUT jack. Input requirements appear in section 2.6.

(2) Rotate FUNCTION switch to the E/UT x 10 position.

(3) Set the TIME switch to "1". At this position of the FUNCTION switch the interval during which events are counted is 10 times that indicated by the TIME switch; therefore, the interval will be 10 seconds.

(4) Adjust the DISPLAY TIME control for a convenient reading.

(5) Adjust the ATTENUATION control as described in section 2.6.

(6) To obtain a reading in events per second divide the reading on the numerals by 10.

(7) Under this type of operation there will be no illuminated digit in the column at the far left, so the count indication will consist of only six digits. Consequently, when measuring frequencies above 100Kcs, the instrument will count up to 999,999, then return to 000,000 (thus completing one full cycle) and begin a second cycle. To measure frequencies in this range, the operator must count the number of full cycles which occur, then multiply this number by 1,000,000 and add it to the final count indication. For example, if the instrument counts through 000,000 six times and ends up indicating 315,728, the total count will be 6,315,728 and the frequency will be 631,572.8cps.

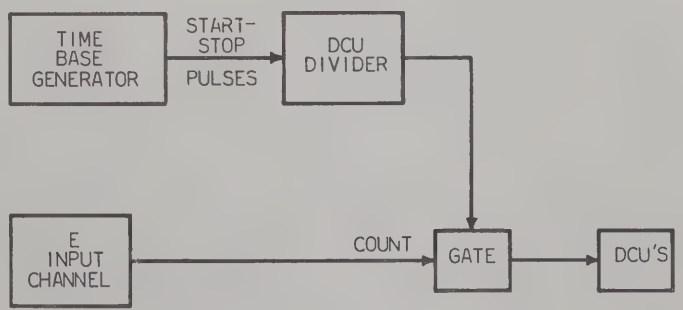


FIGURE 4b

2.5.4 SCAN Operation

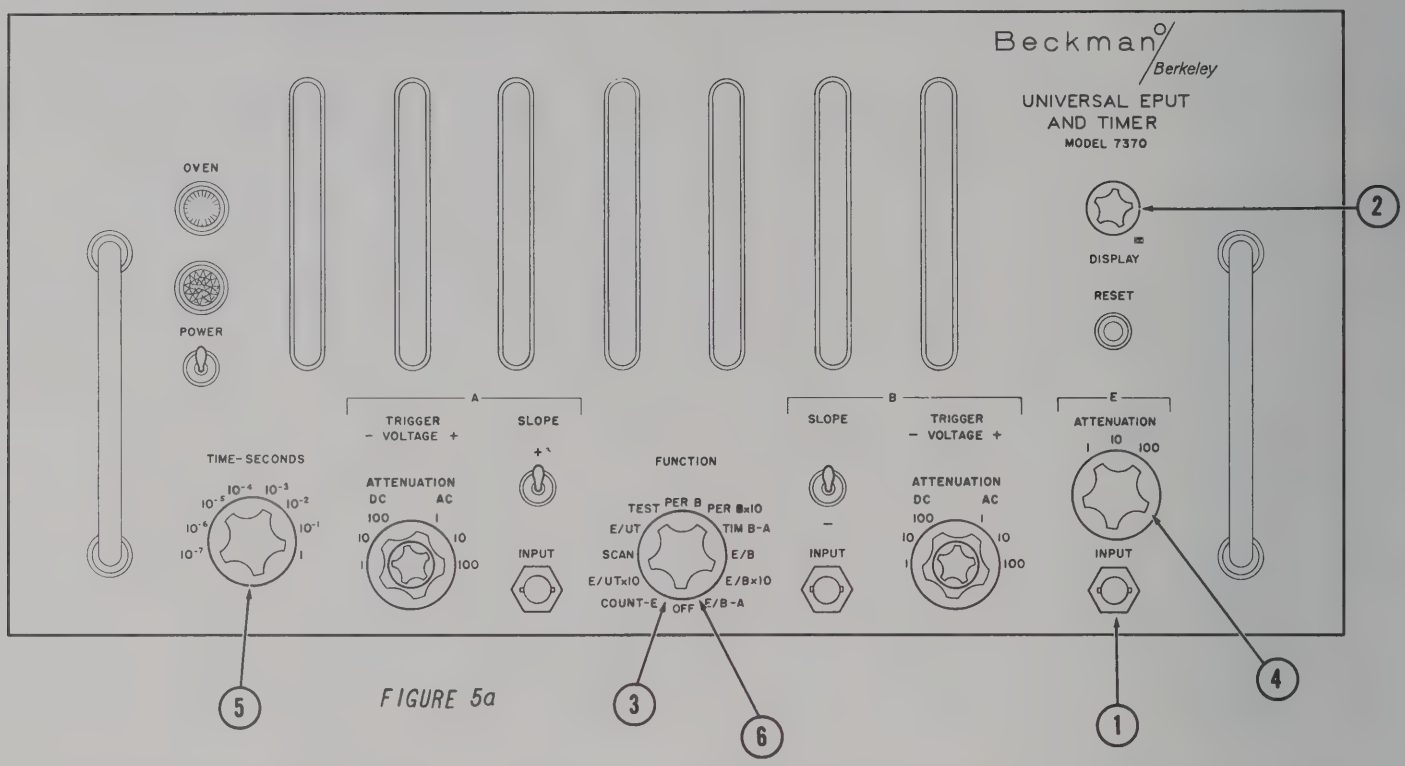


FIGURE 5a

What Kind of Measurement is Made. The interval during which events are counted may be manually extended to any multiple of the one or ten-second counting periods. This provides a method of measuring low frequencies accurately without resorting to a period measurement. For example, the possible error when counting a 60 cps signal for ten seconds under E/UT x 10 operation is one part in 600. This error will be reduced in the same proportion as the counting time is extended. With a counting time of 100 seconds, possible error drops to one part in 6000; with 1000 seconds, to one part in 60,000, and so on. The major components are connected as in figure 5b.

Operating Procedure. To perform this operation, consider the total counting interval desired as N counting periods; then proceed as follows:

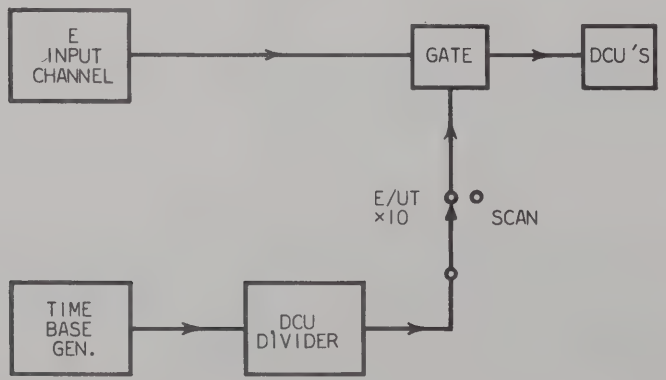


FIGURE 5b

(1) Couple the signal representing events to the E INPUT jack. Input requirements appear in section 2.6.

(2) Turn DISPLAY TIME control clockwise to a stop but not so far that the switch clicks.

(3) Place the FUNCTION switch at E/UT x 10.

(4) Adjust the ATTENUATION control as described in section 2.6.

(5) To select a ten-second automatic counting period, place the TIME switch at "1". To select a one-second automatic counting period, place the TIME switch at 10^{-1}.

(6) The instrument will begin cycling. It will count for one or ten seconds, will hold the count indication for about five seconds, then return to zero and begin counting again. Interrupt one of these cycles as follows: as the instrument starts counting, quickly turn the FUNCTION switch to SCAN and simultaneously begin timing N-minus-one automatic counting periods. At the end of N-minus-one periods, turn the FUNCTION switch back to E/UT x 10. As soon as the instrument stops counting, turn the DISPLAY control clockwise until a switch clicks audibly; this will hold the count indication until you have time to read it. If the automatic counting period is 10 seconds you can time N-minus-one periods with the sweep-second hand of an ordinary watch; if you use a one-second automatic period you will need a stop watch.

(7) To obtain the input frequency in events per second, divide the count indication by the total counting interval in seconds.

2.5.5 E/B Operation

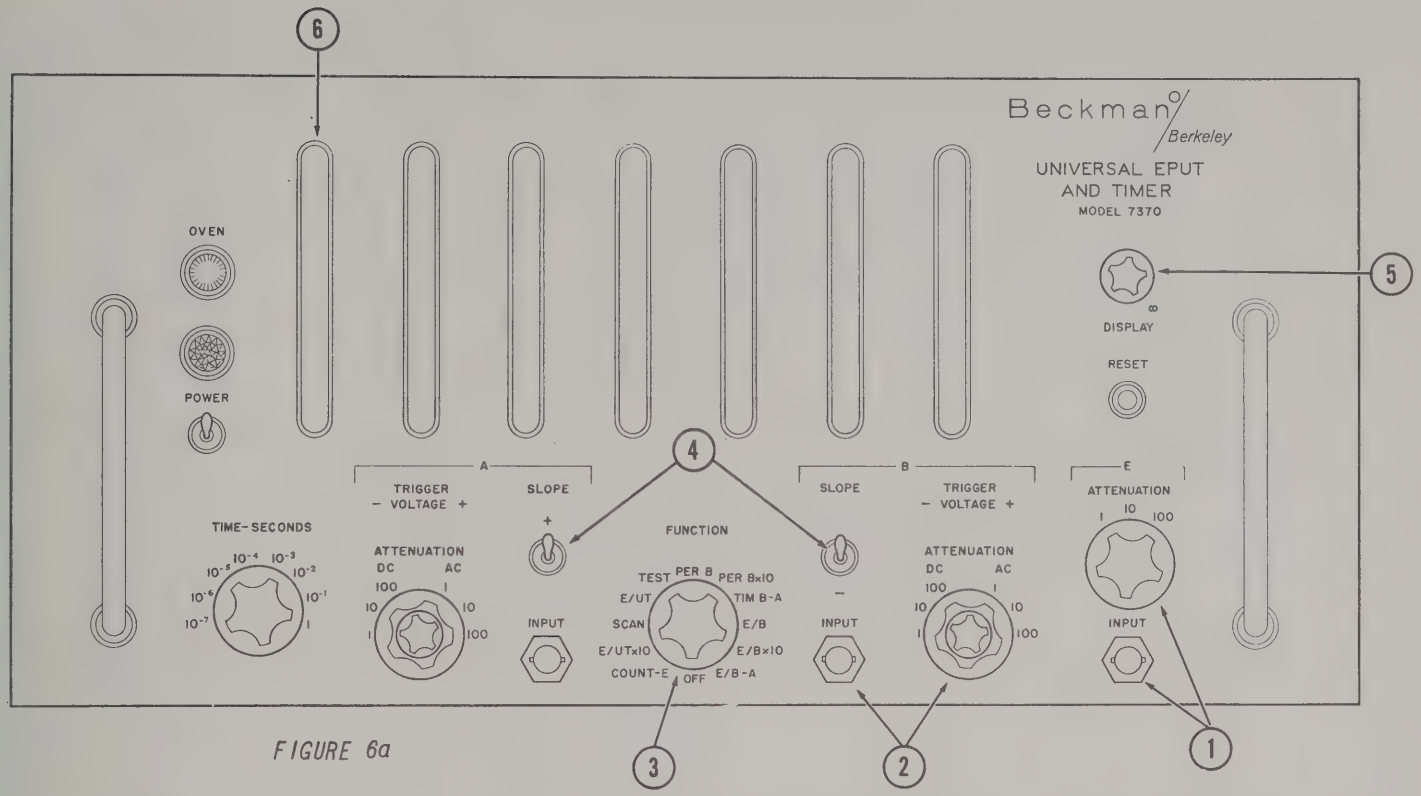


FIGURE 6a

What Kind of Measurement is Made. At the E/B position of the FUNCTION switch the unit counts cycles of the signal at the E INPUT during the interval between consecutive voltage excursions through a selected level at the B INPUT. This setting may be used to measure the ratio of two frequencies or to count the number of events occurring while the B INPUT is above or below a given voltage level. The major components are connected as shown in figure 6b.

Operating Procedure. To make a measurement, proceed as follows:

(1) Connect the higher frequency to the E INPUT jack and adjust the attenuation control as described in section 2.6.

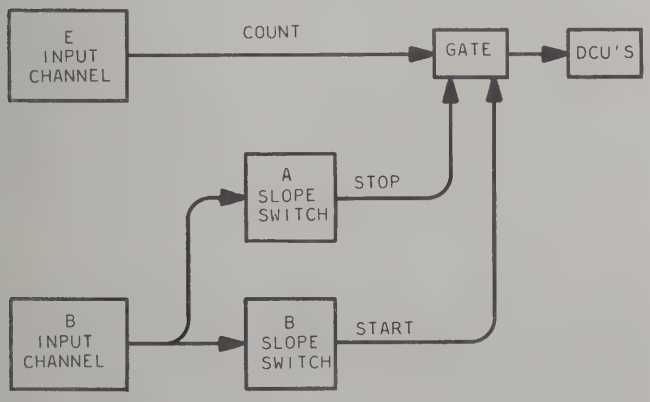


FIGURE 6b

(2) Connect the lower frequency to the B INPUT jack and adjust the "B" ATTENUATION and TRIGGER VOLTAGE controls. (See section 2.7.)

(3) Rotate the FUNCTION switch to E/B.

(4) In this position of the FUNCTION switch the B SLOPE switch determines the polarity of the voltage excursion which starts the count of the E input. The A SLOPE switch sets the polarity of the voltage excursion which stops the counting period. Therefore,

(a) When measuring the ratio of two frequencies set both SLOPE switches to "+" or both to "-".

(b) When counting the E input during the period the B input voltage remains positive of a certain level, set the B SLOPE to "+" and the A SLOPE to "-".

(c) When counting the E input during the period the B input voltage remains negative of a certain level, set the B SLOPE switch to "-" and the A SLOPE switch to "+".

(5) Adjust the DISPLAY control to a position at which the count indication may be read conveniently.

(6) Take a reading. When measuring a frequency ratio the lighted numerals indicate the ratio of the E input frequency to the B input frequency. The reading is always a whole number.

2.5.6 E/Bx10 Operation

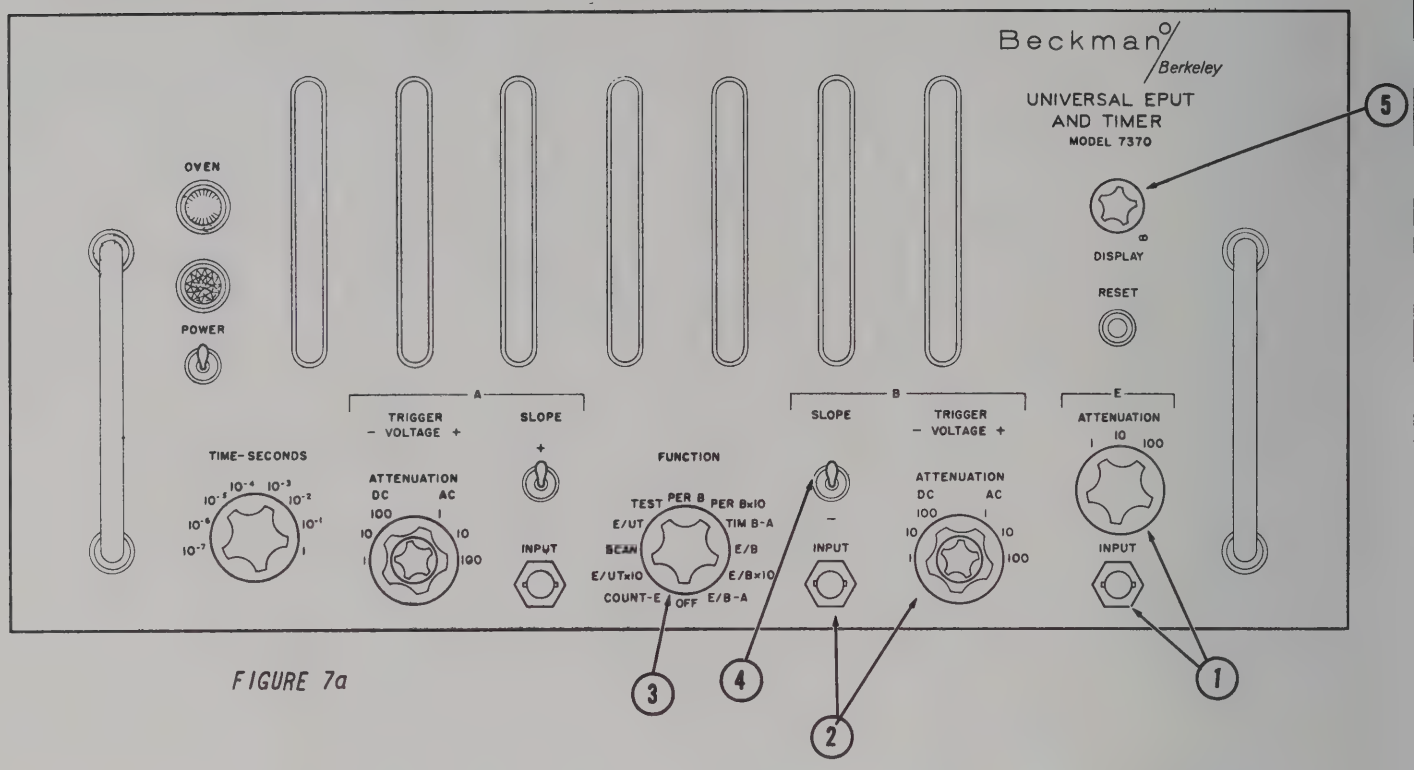


FIGURE 7a

What Kind of Measurement is Made. At the E/B x 10 position of the FUNCTION switch the unit counts cycles of the signal at the E INPUT during the time interval separating every tenth voltage excursion through a selected level at the B INPUT. This setting will measure a frequency ratio more accurately than the E/B operation. The major components are connected as shown in figure 7b.

Operating Procedure. To make a measurement, proceed as follows:

(1) Connect the higher frequency to the E INPUT jack and adjust the E attenuation control as described in section 2.6.

(2) Couple the lower frequency to the B INPUT jack and adjust the "B" ATTENUATION and TRIGGER VOLTAGE controls. (See section 2.7.) The maximum frequency which may be inserted at the B INPUT in this mode of operation is 10 kcs.

(3) Rotate the FUNCTION switch to E/B x 10.

(4) In this position of the FUNCTION switch the B SLOPE switch determines the polarity of the voltage excursion which begins and ends counting. For greatest accuracy set this SLOPE switch on the steeper slope of the B input signal.

(5) Adjust the DISPLAY control to a position at which the count indication may be read conveniently.

(6) Divide the reading by 10 to obtain the ratio of the E INPUT frequency to the B INPUT frequency. During this operation, there will be no illuminated digit in the column at the far left.

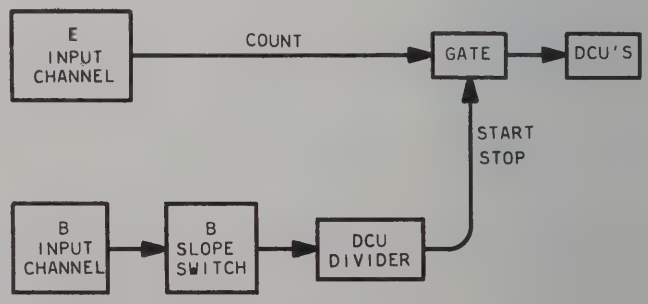


FIGURE 7b

2.5.7 E/B-A Operation

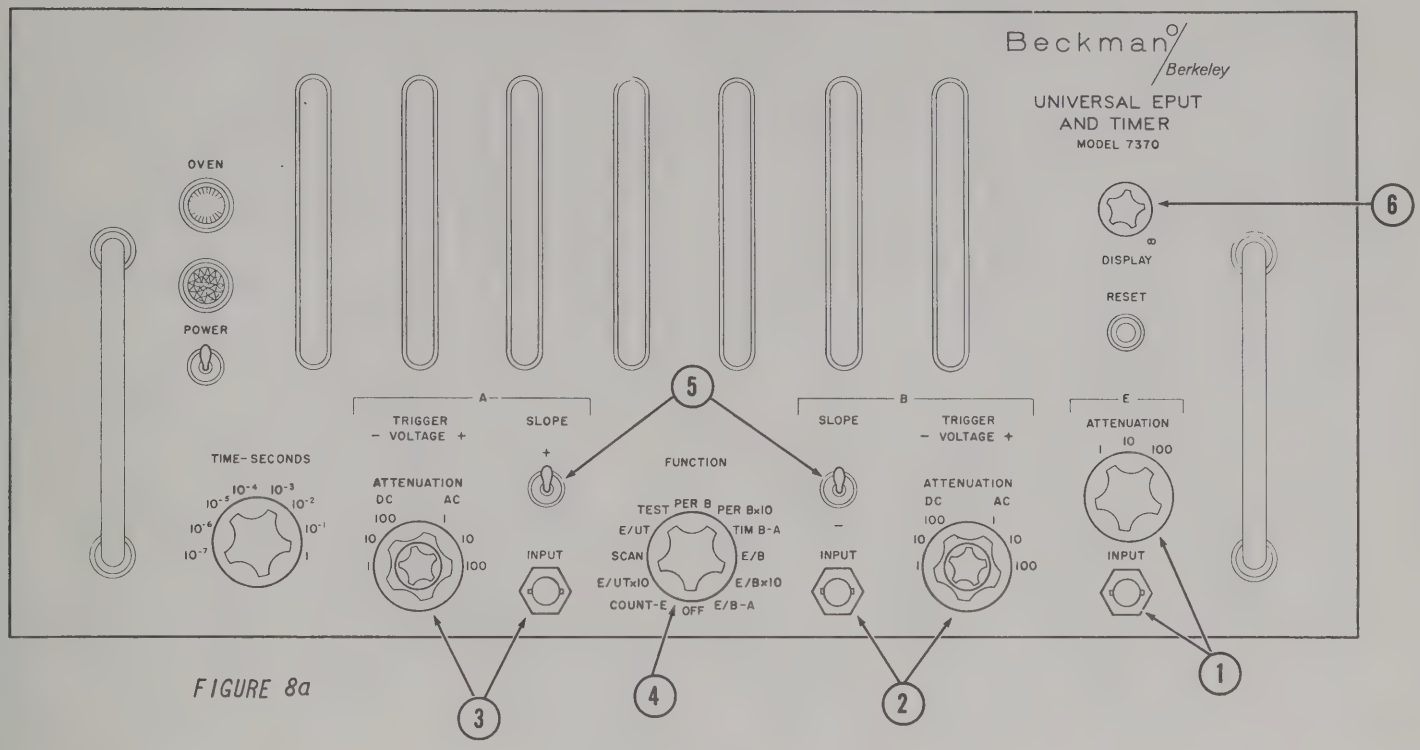


FIGURE 8a

What Kind of Measurement is Made. At the E/B-A position of the FUNCTION switch the instrument counts cycles of the signal at the E INPUT jack between a voltage excursion through a selected level at the B INPUT and a later voltage excursion through an independently chosen level at the A INPUT. The major components are connected as diagrammed in figure 8b. This mode of operation is used to count the number of events occurring between two other events which are represented at separate inputs.

Operating Procedure. To make a measurement, proceed as follows:

(1) Couple the signal representing events to be counted to the E INPUT jack and adjust the E channel attenuation control as described in section 2.6.

(2) Couple the signal which is to start the counting action to the B INPUT jack.

(3) Couple the signal which is to stop the counting action to the A INPUT jack. Adjust the ATTENUATION and TRIGGER VOLTAGE controls for both input channels. See section 2.7 for directions.

(4) Place the FUNCTION switch at E/B-A.

(5) Position the SLOPE switches. The B SLOPE switch determines the polarity of the voltage excursion which will start the counting action; the A SLOPE switch determines the polarity of the excursion which stops the counting action.

(6) Adjust the DISPLAY time control so that the count indication will be displayed as long as desired.

(7) After counting has taken place, read the count indication.

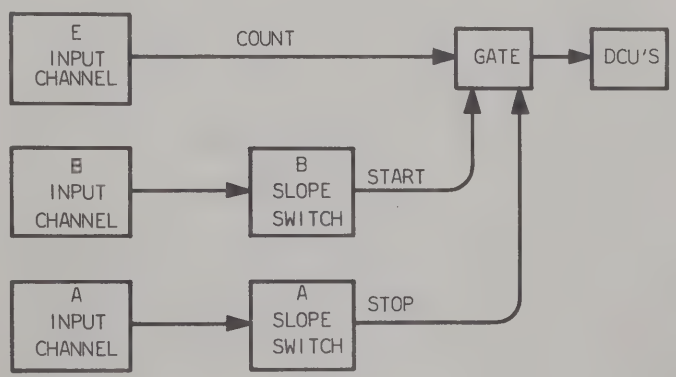


FIGURE 8b

2.5.8 TIM (Time-Interval-Meter) Operation

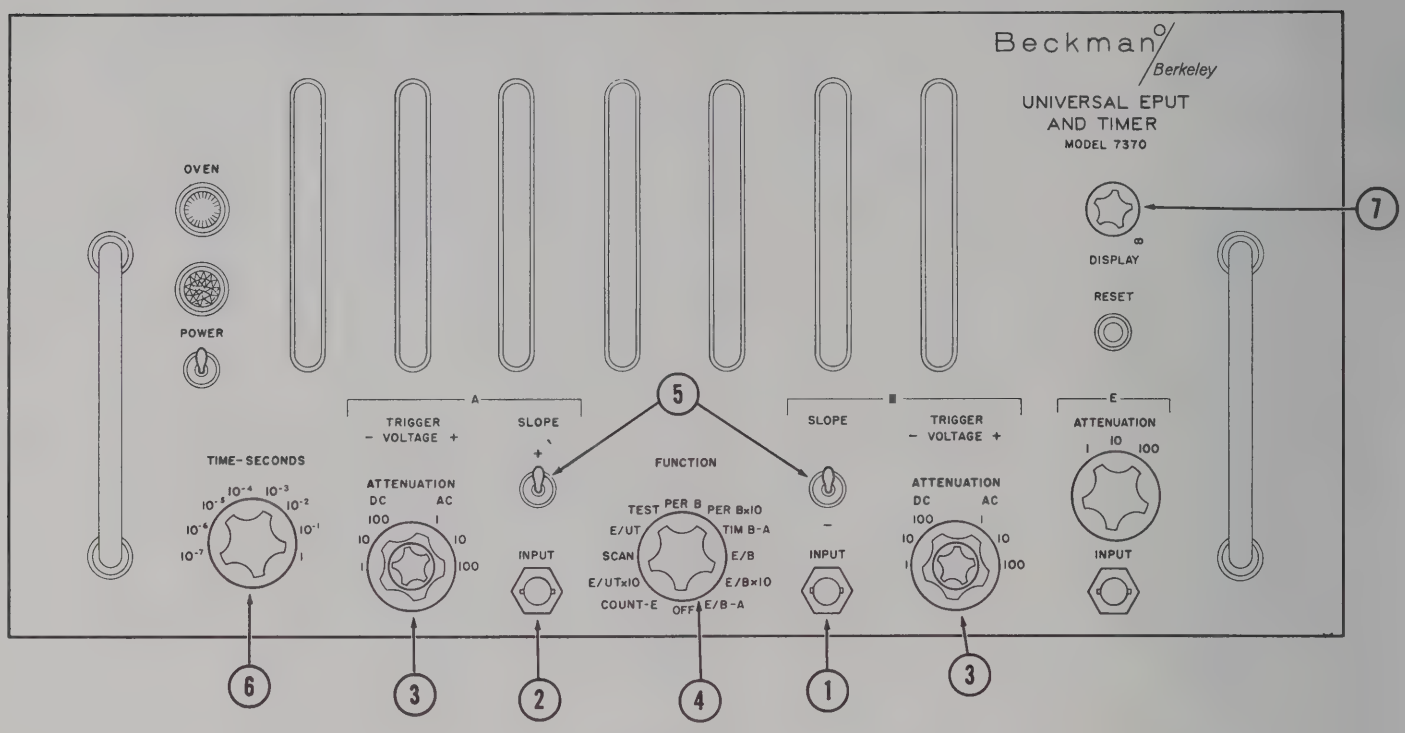


FIGURE 9a

What Kind of Measurement is Made. At TIM B-A position of the FUNCTION switch the unit measures the time between a voltage excursion through a selected level at the B INPUT and a voltage excursion through an independently chosen level at the A INPUT. The major components are connected as shown in figure 9b.

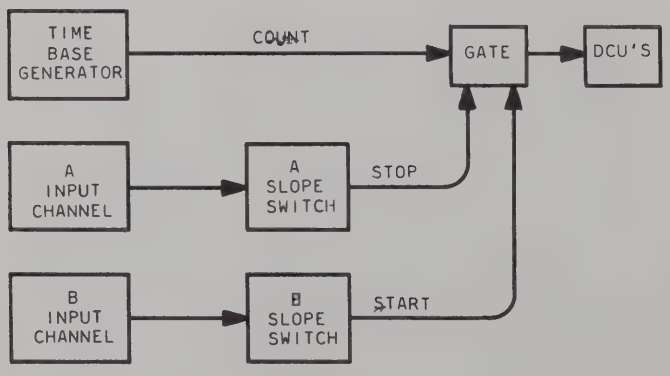


FIGURE 9b

Operating Procedure. To make a measurement, proceed as follows:

1. Connect the start signal to the B INPUT.
2. Connect the stop signal to the A INPUT.
3. Adjust the ATTENUATION and TRIGGER VOLTAGE controls for both input channels as described in section 2.7.
4. Rotate the FUNCTION switch to TIM B-A.
5. In this position the B SLOPE switch selects the polarity of the voltage excursion which starts the timing period. The A SLOPE switch selects the polarity of that which stops the timing period.
6. Rotate the TIME switch to the desired unit of time measurement. For example, at the 10^{-4} position the time measurement appears in ten-thousandths of a second. The smaller the time unit chosen, the more accurate the reading.
7. Adjust the DISPLAY time control to a position at which the count indication may be read conveniently.

2.5.9 PERIOD Operation

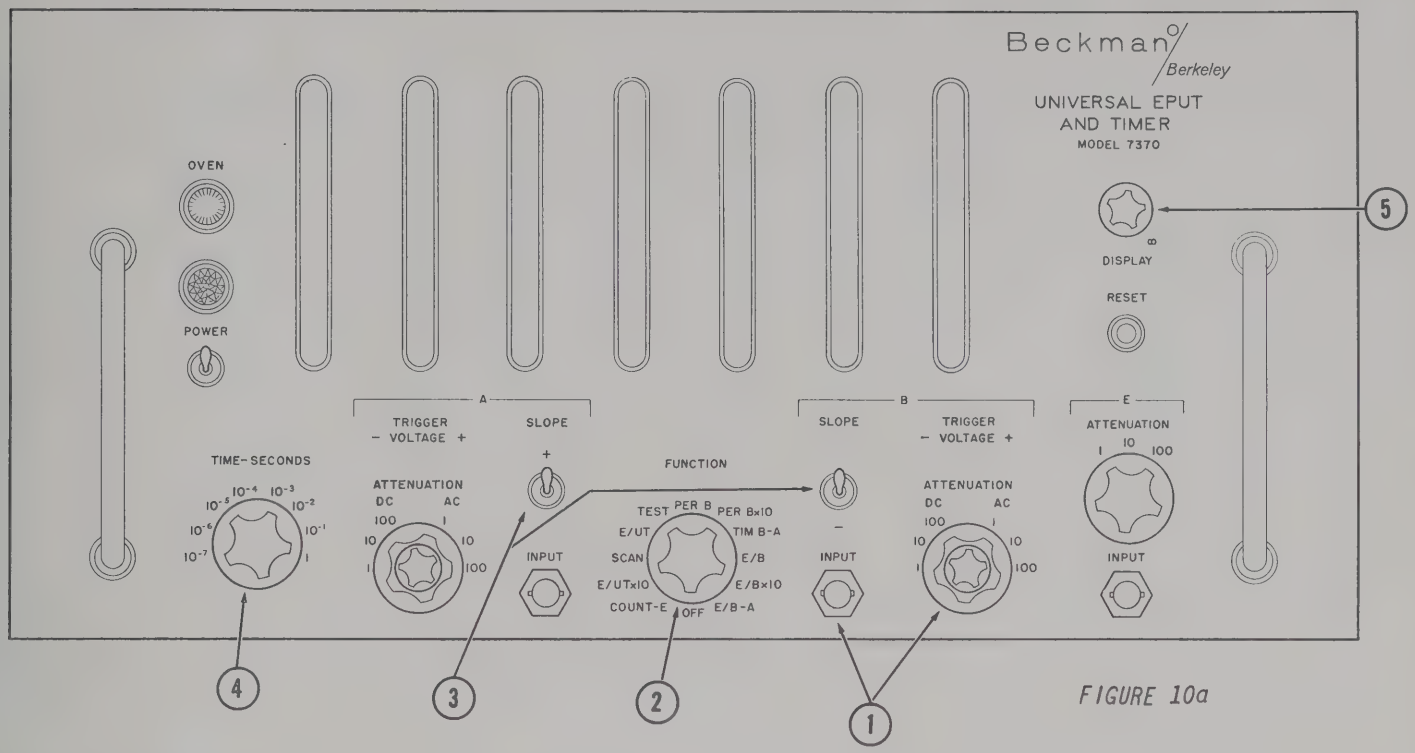


FIGURE 10a

What Kind of Measurement is Made. At the PER B position of the FUNCTION switch the unit measures the time interval between consecutive voltage excursions through a selected level at the B INPUT. This setting may be used to measure the period of a wave or the width of a pulse. The major components are connected as in figure 10b.

Operating Procedure. To make a measurement, proceed as follows:

(1) Connect the wave or pulse source to the B INPUT. Adjust the B ATTENUATION and TRIGGER VOLTAGE control. (See section 2.7).

(2) Turn the FUNCTION switch to PER B.

(3) At this position of the FUNCTION switch the B SLOPE switch selects the polarity of the voltage excursion which starts the timing period. The A SLOPE switch selects the polarity of that which stops the timing period. Therefore,

(a) When measuring the period of a wave, set both SLOPE switches to "+" or both to "-".

(b) When measuring the width of a positive pulse, set the B SLOPE switch to "+" and the A SLOPE switch to "-".

(c) When measuring a negative pulse, set the B SLOPE switch to "-" and the A SLOPE switch to "+".

(4) Rotate the TIME switch to the desired unit of time measurement. For example, at the 10^{-3} position the time measurement appears in thousandths of a second. The smaller the time unit chosen, the more accurate the reading.

(5) Adjust the DISPLAY time control to a position at which the count indication may be conveniently read.

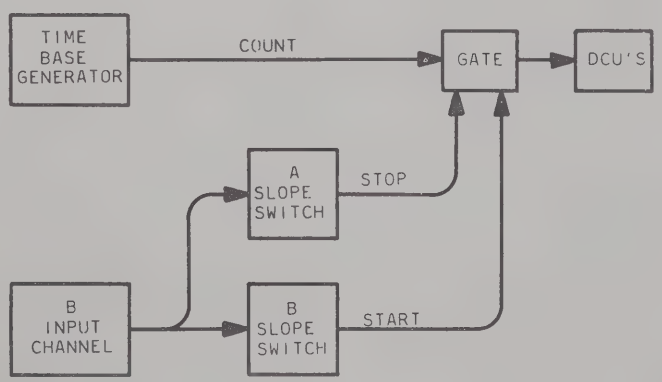


FIGURE 10b

2.5.10 PERIOD x 10 Operation

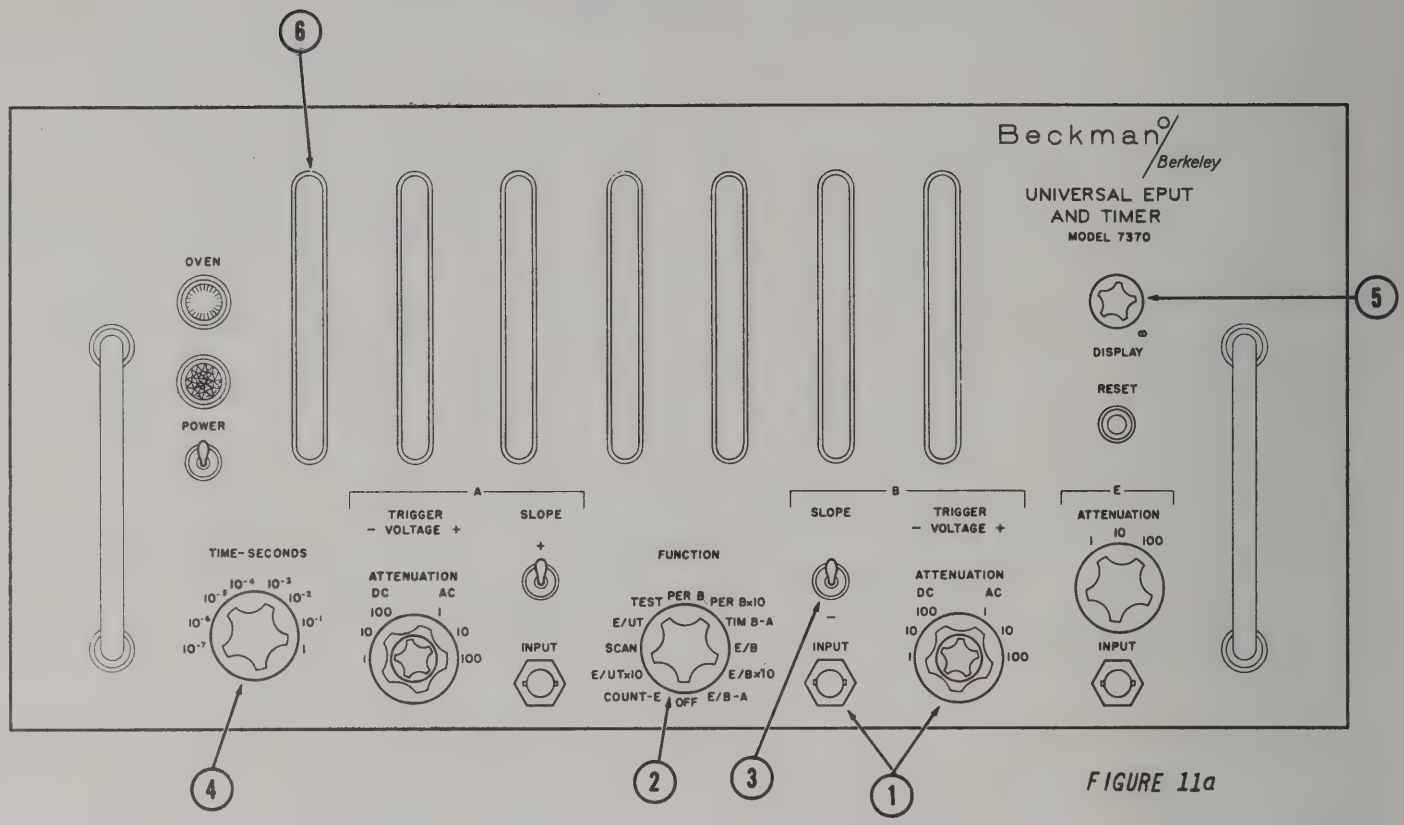


FIGURE 11a

What Kind of Measurement is Made. The instrument measures the time interval separating every tenth voltage excursion through a selected level at the B INPUT. This setting will measure the period of a wave more accurately than the PERIOD operation. The major components are connected as diagrammed in figure 11b.

Operating Procedure. To make a measurement, proceed as follows:

(1) Connect the wave source to the B INPUT. The maximum frequency which may be inserted at the B INPUT in this mode of operation is 10 KC. Adjust the B ATTENUATION and TRIGGER VOLTAGE controls as described in section 2.7.

(2) Rotate the FUNCTION switch to PER B x 10.

(3) The B SLOPE switch selects the polarity of both start and stop voltage excursions.

(4) Rotate the TIME switch to the desired unit of time measurement. For example, at the 10^{-3} position the time measurement appears in thousandths of a second. The smaller the time unit chosen, the more accurate the reading.

(5) Adjust the DISPLAY time control to a position at which the count indication may be read conveniently.

(6) Divide the reading by 10 to obtain the time of one period. There will be no lighted digit in the column at the far left during this mode of operation.

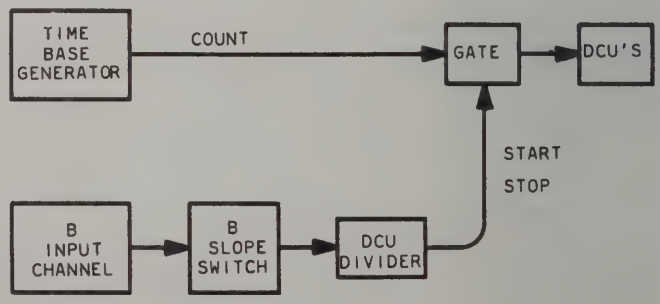


FIGURE 11b

2.5.11 COUNT Operation

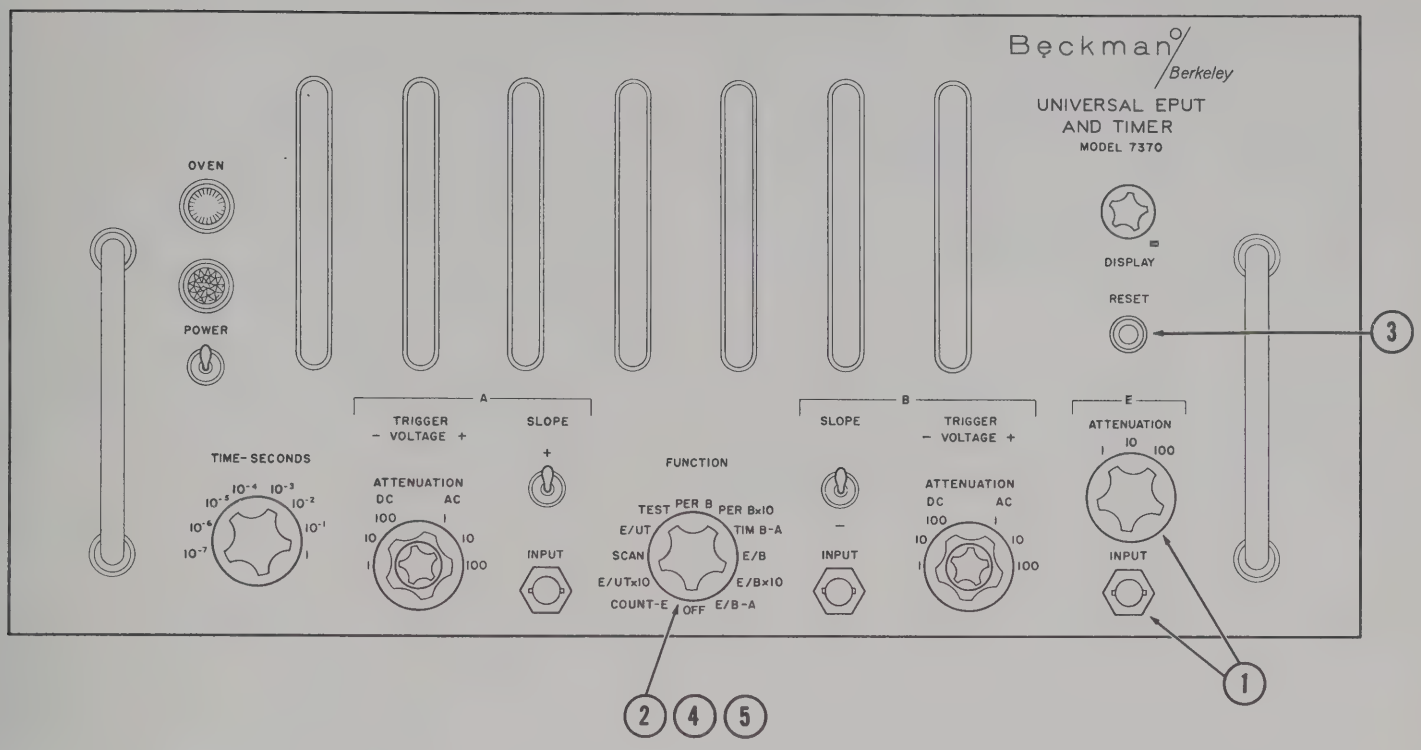


FIGURE 12a

What Kind of Measurement is Made. The unit counts cycles of the signal at the E INPUT jack during the period the FUNCTION switch is in the COUNT position. The major components are connected as diagrammed in figure 12b.

Operating Procedure.

(1) Connect the input signal to the E INPUT jack. Adjust the attenuation control as described in section 2.6.
(2) Turn the FUNCTION switch to OFF.
(3) Depress manual RESET button.
(4) Turn the FUNCTION switch to COUNT to begin the counting action.
(5) Turn the FUNCTION switch to OFF to stop the counting action.
(6) Read the count indication. Counting can be continued without erasing the previous indication by turning the FUNCTION switch back to COUNT.

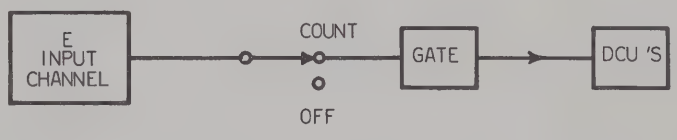


FIGURE 12b

2.6 HOW TO ADJUST THE "E" INPUT CHANNEL

The signal introduced at the E INPUT jack must have an amplitude of at least 0.3 volts peak-to-peak and a frequency lying between 10 cps and 10 Mcs. The impedance at the INPUT jack is one megohm in parallel with 40$\mu\mu$f. This impedance may be reduced to match the source or to avoid capacitive pick-up by attaching a "T" connector to the jack and adding resistors or capacitors in parallel. Input voltages as high as 400v peak-to-ground may be applied without damaging the circuit.

An attenuation control is provided to attenuate the input voltage by a factor of 100, 10 or 1, thus creating input sensitivities of 30v, 3v or 0.3v peak-to-peak. Set the control at the highest attenuation factor at which the instrument will count every cycle of the signal applied at the INPUT. The best way to discover if some cycles are not being counted is to set up the instrument to make an events-per-unit-time measurement as described in section 2.5.2. Then note whether successive count indications vary more than the probable variation in input frequency. If some cycles are failing to trigger the count indication will usually vary so widely that it is easy to distinguish from variation due to input frequency drift. If gross variations do occur, reduce the amount of attenuation or increase the amplitude of the input signal.

2.7 HOW TO ADJUST THE "A" AND "B" INPUT CHANNELS

These input channels are identical. All the information in this section applies to both. Figure 13 is a block diagram of one of these input channels.

Input coupling. The ATTENUATION control selects either a-c or d-c coupling as well as the degree of attenuation. With the control on the side labelled "D-C" the entire input signal, including any d-c level on which it may ride, is direct-coupled to the attenuator. When the control is on the side labelled "A-C" a .01μf blocking capacitor is inserted between the input jack and the attenuator.

Attenuation. The input voltage will be divided by the factor to which the ATTENUATION control is set. This permits the operator to select any of

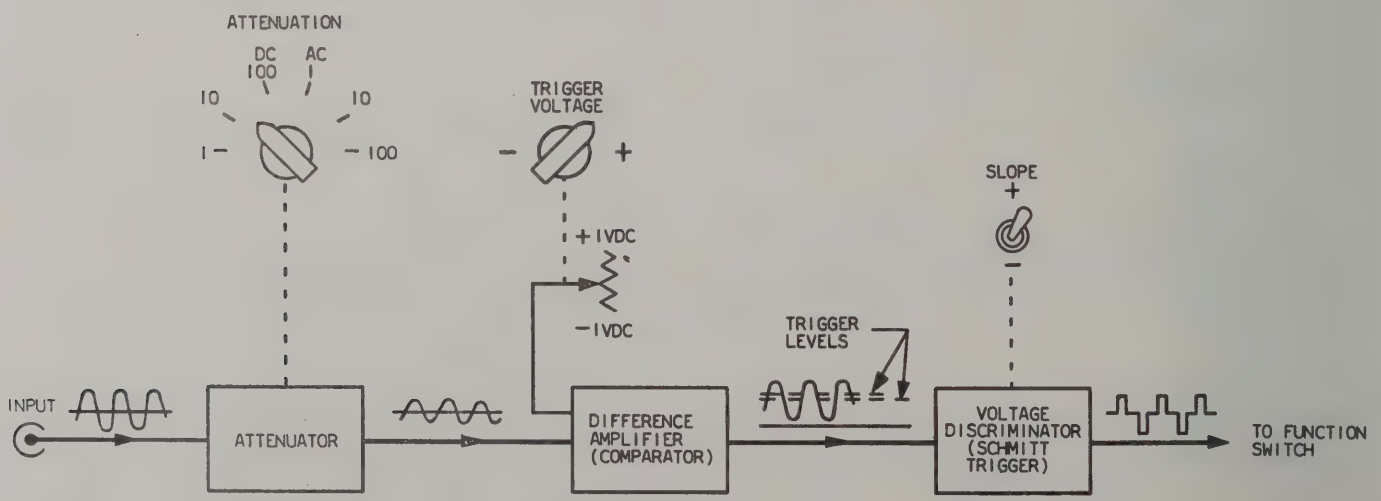


FIGURE 13. BLOCK DIAGRAM, INPUT TRIGGER CHANNEL.

three input sensitivities: 0.6v peak-to-peak with the control at "1", 6v with the control at "10" or 60v with the control at "100".

With d-c coupling the impedance at the INPUT jack is one megohm in parallel with 40$\mu\mu$f. The .01μf capacitor inserted in series when the signal is a-c coupled does not affect the impedance appreciably unless the input frequency is below 10 cps. The input impedance may be reduced to match the source or to avoid capacitive pickup by attaching a "T" connector to the jack and adding resistors or capacitors in parallel. Input sensitivity is equal to 0.6 volts peak-to-peak times the factor to which the ATTENUATION control is set. The input circuitry will withstand a signal as strong as 500 volts peak-to-ground without damage.

The input signal may have any frequency from d-c to 3 Mcs. However, if the signal is a-c coupled it must have sufficient amplitude to overcome the attenuating effect of the .01μf blocking capacitor.

Method of triggering. Figure 14 shows how the varying voltage of the attenuated signal triggers channel output pulses. A pulse is produced each time the instantaneous voltage of the attenuated signal passes through the "positive-going trigger voltage" level. When the SLOPE switch is at "+", only pulses triggered by positive-going voltage excursions affect the succeeding circuitry. With the SLOPE switch at "-", only pulses triggered by negative-going excursions are effective.

The two trigger voltage levels (positive-going and n negative-going) are always separated by 0.6 volts, the effective hysteresis. Because a voltage excursion must travel through both levels to trigger a pulse, the sensitivity of the channel to the attenuated signal is 0.6 volts peak-to-peak.

The trigger voltage levels are raised or lowered simultaneously (maintaining 0.6-volt separation) when the TRIGGER VOLTAGE control is rotated. This control will vary the levels from roughly -1 volt to +1 volt. Referring to figure 13 notice that the TRIGGER VOLTAGE control actually raises or lowers the d-c level of the input to the voltage discriminator. However, this action has the effect of raising or lowering the trigger voltage levels at the input to the difference amplifier.

Using the controls. The purpose of the input trigger channel is to produce a reliable pulse output representing that part of the input signal in which the operator is interested. This is achieved only when the ATTENUATION and TRIGGER VOLTAGE controls are properly adjusted. Before attempting to adjust the controls, it is best to visualize the input waveform, noting the shape, a-c amplitude and d-c level. The effect of various control settings is

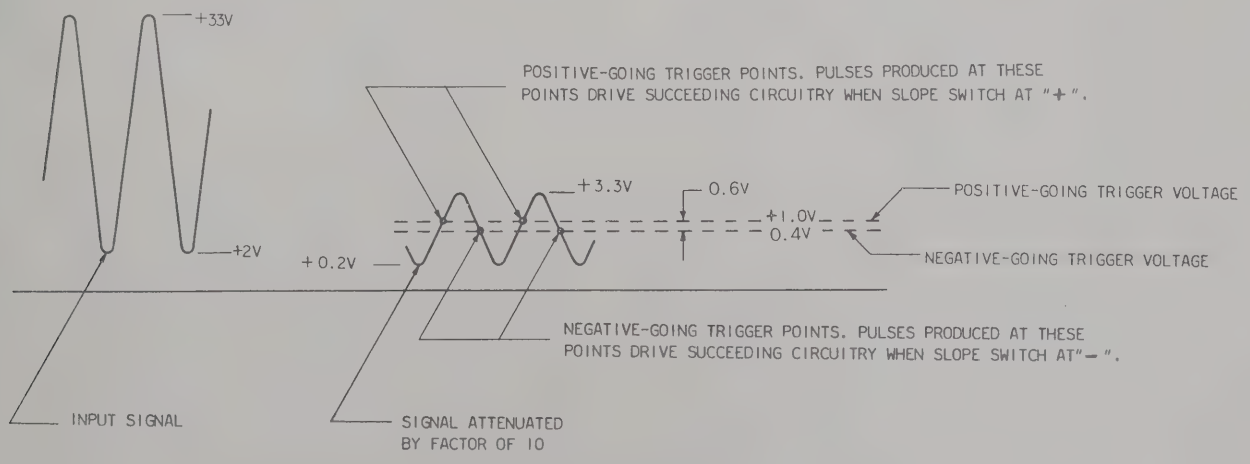

+33V
+2V
+0.2V
+3.3V
0.6V
+1.0V
0.4V
POSITIVE-GOING TRIGGER POINTS. PULSES PRODUCED AT THESE POINTS DRIVE SUCCEEDING CIRCUITRY WHEN SLOPE SWITCH AT "+".
POSITIVE-GOING TRIGGER VOLTAGE
NEGATIVE-GOING TRIGGER VOLTAGE
NEGATIVE-GOING TRIGGER POINTS. PULSES PRODUCED AT THESE POINTS DRIVE SUCCEEDING CIRCUITRY WHEN SLOPE SWITCH AT "-".
INPUT SIGNAL
SIGNAL ATTENUATED BY FACTOR OF 10

FIGURE 14.

then relatively easy to calculate. Referring to figure 14, notice that:

1. If the attenuated signal is small peak-to-peak, the trigger voltage levels may be set so high or so low that no pulses are produced. For example, if the "positive-going trigger voltage" were set at -0.5 volts (thus placing the "negative-going trigger voltage" at -1.1 volts), the attenuated signal with peaks at +0.2 and +3.3 volts would not intersect either trigger voltage level.
2. If the attenuated voltage variations ride on a d-c level, they may not come within the trigger voltage range. If the input signal were not attenuated (or a-c coupled) the negative peak at +2 volts would not intersect any possible trigger voltage level.
3. Modulation or variations in the d-c level of the attenuated signal are least likely to cause a failure to trigger if the trigger voltages are set about halfway between the peaks of the signal.
4. Extraneous signals (noise, hum, modulation, drift, etc.) have the least effect on the time at which a pulse occurs when the channel triggers on a steep slope of the waveform.
5. Noise below 0.6 volts peak-to-peak will not trigger extraneous pulses. Consequently, attenuating a signal carrying a given percentage of noise may eliminate the effect of the noise. For example, 1 volt peak-to-peak noise on an 8 volt peak-to-peak signal will trigger extraneous pulses. If the signal is attenuated by a factor of 10, the resulting 0.8 volt p-p signal will still trigger desired pulses dependably, while the resulting 0.1 volt p-p noise is well below the sensitivity of the channel.
6. Attenuating the input signal
   (a) Reduces the slope at all points
   (b) Shifts the a-c component nearer ground if it rides on a d-c level.
   (c) Increases the minimum peak-to-peak variations necessary to trigger pulses (measured at the INPUT jack) from 0.6 volts to 6 or 60 volts.
   (d) Increases the range of possible trigger voltage setting on the input signal from ±1 volt to ±10 volts or ±100 volts.

Adjustment of ATTENUATION and TRIGGER VOLTAGE controls should be made keeping the above characteristics in mind. If the input is a regular, periodic signal you can tell whether each cycle is triggering a pulse by attempting to measure the time between pulses. If the successive time measurements do not vary more than 20 percent, you can be reasonably certain that every cycle is triggering a pulse. Variations under 20 percent will be caused by noise. In the case of the B channel, the time measurement can be made by setting up the instrument for PERIOD B operation. When adjusting the A channel, use TIM B-A operation with the A INPUT signal coupled through a "T" connector to the B INPUT also. In this case you must adjust both the A and the B channel controls.

The point on an input waveform where the input channel triggers may be seen on an oscilloscope. Observe the input of the voltage discriminator in the input channel used (V302, Pin 7). The waveform which appears is the amplified input signal together with small "notches" created on each slope as the channel triggers. The TRIGGER VOLTAGE control will cause these notches to move up and down the waveform. See "Typical Waveforms" for a sample display.

The trigger voltage may be set at a precise value by applying a d-c voltage of that value at the INPUT jack, setting the ATTENUATION control at an appropriate factor on the DC side and rotating the TRIGGER VOLTAGE control to the point where an output pulse is produced. With no input voltage, the input jack lies at ground and a pulse will be produced at ground level.

Some information about the position of the trigger voltage relative to the signal may be extracted from the instrument itself. The trigger voltage may be varied between the positive and negative peaks of an attenuated signal whose peaks lie within the range -1 to +1 volts. As the trigger voltage passes beyond the signal peaks the pulse output of the channel will cease, and these positions of the control may be noted.

2.8 ACCURACY

2.8.1 Measurements are subject to four important sources of error.

1. Counts missed or added as the Gate opens and closes.
2. Clock signal inaccuracy.
3. Errors in the time at which a "start" or "stop" pulse occurs in cases where these pulses are triggered by an input signal.
4. Counts missed because they occur during the resolution time of the counting circuits.

2.8.2 Gating Error. Pulses which occur simultaneously with the opening or closing of the Gate may or may not be counted. This causes all measurements to vary plus or minus one count. The following equation defines the possible error introduced.

$$\text{Max. \% error} = \frac{1}{\text{Count Indication}} \times 100 \quad (1)$$

Notice that measurements set up to yield the highest count indication will be most accurate.

The frequency of a sine wave signal can be measured directly by counting events-per-unit-time or indirectly by measuring the length of one period and calculating the frequency. Higher frequencies yield the highest count indication when measured directly, that is, using the E/UT or E/UT x 10 function. Lower frequencies produce the highest indication when rapid time signals are counted over one or ten periods, that is, using the PER B or PER B x 10 function. Frequencies above 3160 cps produce the highest count indication when measured using the E/UT x 10 function and a 10-second time interval (TIME switch set at "1"); frequencies below 3160 cps yield the highest count when measured with the PERIOD x 10 function and a 0.1μsecond unit of time measurement. The accuracy achieved using alternative

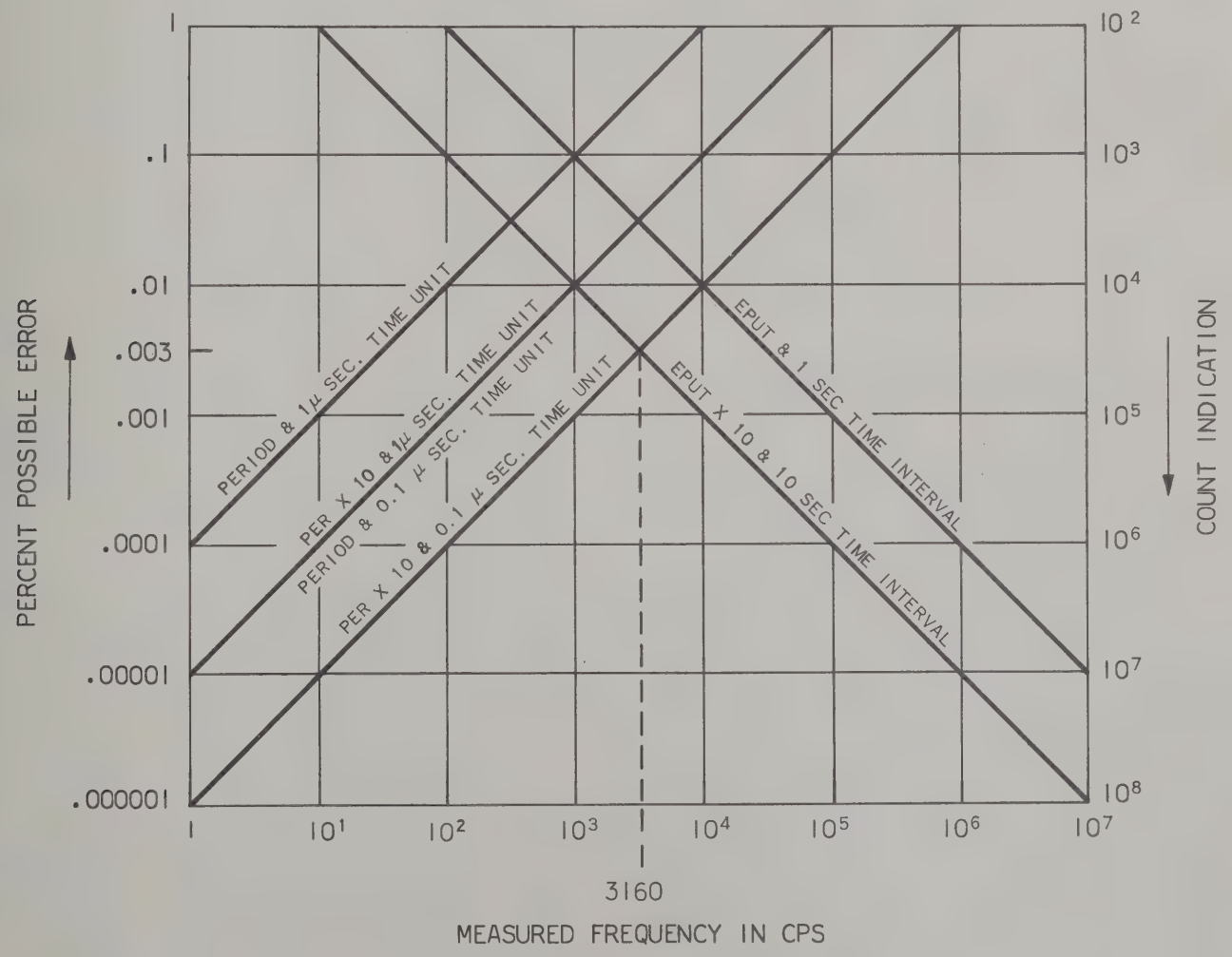


FIGURE 15. GATING ERROR PLOTTED AGAINST FREQUENCY AND MODE OF OPERATION.

functions at various frequencies is graphically illustrated in Figure 15. Note that the curves for E/UT x 10 (10 second interval) and PERIOD x 10 (0.1μsec time unit) cross at 3160 cps. This frequency cannot be measured with a possible error less than .003 percent. Frequencies above and below may be measured with greater accuracy.

2.8.3 Clock Signal Error. All measurements requiring a time signal are subject to an additional error introduced by variations in the oscillator frequency. The oscillator frequency in the Model 7370 is stable to 3 parts in 10^7 per week, so it can cause a maximum error of only .00003 percent.

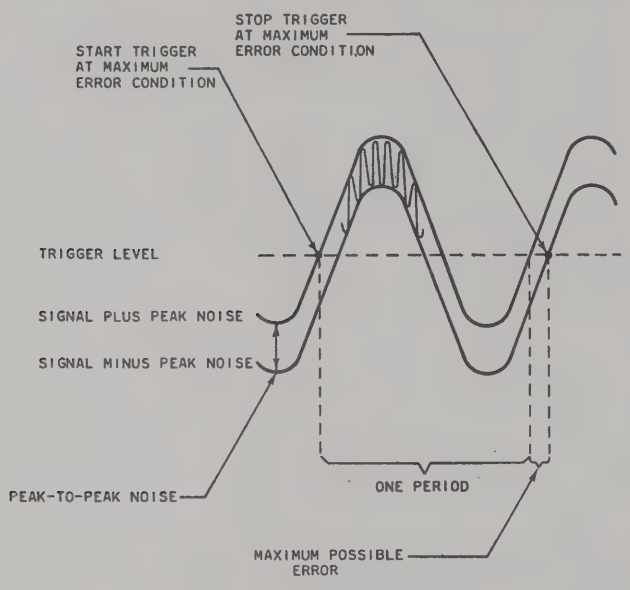


FIGURE 16. EFFECT OF NOISE ON ACCURACY OF PERIOD MEASUREMENT.

2.8.4 Error due to Noise on "Start" or "Stop" Input Signal. Measurements using an external signal to trigger start and stop pulses (i.e. PER B, PER B x 10, TIM B-A, E/B, E/B x 10 and E/B-A) be subject to a further error caused by pulses which are triggered too soon or too late. Refer to Figure 18 which illustrates what occurs during a simple period measurement.

Consider the total signal as an ideal signal intended to trigger the input channel plus a noise signal. The noise voltages added or subtracted from the ideal signal may trigger a pulse before or after the instant at which counting should begin or end. The maximum error in the time of triggering will be proportional to the noise amplitude and inversely proportional to the slope of the ideal signal at the trigger level. Expressed mathematically,

$$t\ (\text{secs}) = \frac{V_n\ (\text{volts})}{S\ (\text{volts/sec})} \qquad (2)$$

where t = Max. error in trigger time

V_n = peak-to-peak noise

S = slope of ideal signal at trigger level

The total noise (V_n) is equal to that carried by the input signal after attenuation plus that internally generated by the input channel. The internal noise (which takes the form of amplifier drift, trigger level jitter, line frequency pick-up, etc.) is not more than 300 microvolts. Note that as the amplitude of the input signal is increased, S in equation (2) becomes larger and the internal noise causes less error.

The percentage error may be calculated by dividing the error in trigger time by the counting period and multiplying by 100. In the common case of a period measurement of a sine wave triggering at its zero cross-over value:

$$\text{Max. \% error} = \frac{V_n\ (\text{volts})}{V_S\ (\text{volts}) \times \pi} \times 100 \qquad (3)$$

where V_n = peak-to-peak noise

V_S = peak-to-peak signal

The maximum percent error of a PERIOD x 10 measurement is one-tenth the value given in equation (3). If TIM B-A or E/B-A are being measured, the total noise error is equal to the error in the B input plus that in the A input.

The total error due to the three causes mentioned above is equal to the sum of the separate errors. Total Max. percent error equals:

$$\frac{100}{\text{Count Indication}} + .00003 + \text{Percent error due to noise}$$

If E/UT E/UT x 10 PER B PER B x 10 TIM B-A	If PERIOD PERIOD x 10 TIM, E/B, E/B x 10 or E/B-A

2.8.4 Resolution Error. Another source of error becomes important when random events are counted. One such event may occur immediately after another, before the counting circuits are fully recovered and prepared to register it. The second event will not only fail to cause a count but its effect on the circuitry may cause a third event to fail to register also. Formulae for calculating the counting error due to this effect may be found in "Application of Probability Theory to Nuclear Particle Detection", L.J. Rainwater and C.S. Wu, Nucleonics, October 1947. The minimum time which must elapse between events if both are to be counted is called resolution time of the instrument. This instrument has a resolution time of better than 0.1 μseconds.

2.9 AUXILIARY CONNECTORS

Digital Recorder Jack. Each DCU generates a 4-line code representing the digit it is displaying. These lines are collected at the DIGITAL RECORDER socket at the rear of the instrument. The Model 1452 Digital Recorder plugs directly into this socket. The socket also makes mutual control connections between the counter and the recording device.

The tables below give the code and the pins at which it appears. In the code "0" represents a voltage 15 or more volts negative of ground; "1" represents a voltage at ground or positive of ground.

DECIMAL DIGIT REGISTERED	FOUR - LINE BINARY CODE			
	1st Binary Stage	2nd Binary Stage	3rd Binary Stage	4th Binary Stage
0	0	0	0	0
1	1	0	0	0
2	0	1	0	0
3	1	1	0	0
4	0	1	1	0
5	1	1	1	0
6	0	0	1	1
7	1	0	1	1
8	0	1	1	1
9	1	1	1	1

	PIN NO. ON DIGITAL RECORDER SOCKET			
	1st Binary Stage	2nd Binary Stage	3rd Binary Stage	4th Binary Stage
Highest order digit read	Pin 28	Pin 27	Pin 26	Pin 25
2nd highest order digit	4	3	2	1
3rd highest order digit	8	7	6	5
4th highest order digit	12	11	10	9
5th highest order digit	16	15	14	13
6th highest order digit	20	19	18	17
7th highest order digit	24	23	22	21

Pin 39 carries a control signal from the counter to the recorder. This pin is negative (-10 volts or more) during the display period, and at approximately ground potential from the time of reset to the end of the next counting period. Source impedance at pin 39 is nominally 500K shunted by 100$\mu\mu$f.
Pin 40 carries an "inhibit reset" signal from the recorder to the counter. When this pin is grounded the counter cannot reset.
Pin 38 is grounded, and pins 29 thru 37 remain unconnected.

TIME Jack. The output signal of the time-base generator is available at this jack. The signal consists of positive pulses 5 volts in amplitude. The positive transients are accurately spaced at the interval indicated by TIME switch. These transients can be used externally as a clock signal. The negative transients occur at the same frequency but are not so accurately spaced. The output impedance is 300 ohms.

FREQ Jack. A sine-wave signal at the oscillator frequency is available at this jack when the EXT-INT switch is in INT. The signal is 10 volts peak-to-peak at 3000 ohms impedance. When the EXT-INT switch is at EXT, an external signal can be introduced at this jack to substitute for the oscillator signal. The external signal must have an amplitude of at least 3 volts rms.

SCOPE Jack. This jack is connected through a 220K resistor to the suppressor grid of the gate tube. The voltage at the jack is at about ground level when the gate is open and about -10 volts with respect to ground when the gate is closed. If the waveform of a signal which generates start-stop pulses is displayed on an oscilloscope, the signal at the SCOPE jack (after suitable conversion) may be used to blank the scope during the period the gate is closed. The scope will then display the portion of the waveform whose duration is being measured.

2.10 USING AN EXTERNAL REFERENCE FREQUENCY

An external reference frequency may be substituted for the internal oscillator signal. Introduce the external signal at the FREQ jack and place the TIME switch at a position which produces a clock pulse frequency equal to the reference frequency divided by the desired power of 10. See "FREQ. Jack" under section 2.9 for directions on inserting the external signal.

2.11 REMOTE CONTROL OF OPERATING CYCLE

The counter can be controlled from a remote location so that it will not reset and begin another count until desired. Set the DISPLAY time control at a minimum and connect a wire from the remote location to Pin 40 of the DIGITAL RECORDER socket at the rear of this instrument. As long as this lead is grounded the counter will not reset after completing a counting period. When the lead is ungrounded, the counter will reset within 50 milliseconds and be ready to start counting when a start pulse appears. As soon as the counter has reset, the lead may be grounded again or left ungrounded. It will not affect the operating cycle until the time arrives for the next automatic reset. At that time it must be grounded again to prevent reset.

3.1 ROUTINE ADJUSTMENTS

3.1.1 Regulated 120 Volt Supply. With an accurate voltmeter, measure the voltage between the test jack labeled "+120" (located at the top of the chassis) and ground. If necessary, adjust the +120 V ADJUST control on the rear panel of the instrument for a reading of 120 volts.

3.1.2 Oscillator Frequency. The frequency of the 1 mc oscillator can be varied by rotating the XTAL ADJ control (C410) on the top side of the chassis. This frequency has been adjusted to within one part in 10^7 at the factory; therefore, do not disturb the control unless a frequency standard at least that accurate is available. If a precise 1 mc signal is available use it to form a Lissajous pattern with the oscillator signal which appears at the FREQ jack. Couple the signal at the FREQ jack to the vertical input of a scope. Be sure the scope input impedance is not less than 10 megohms in parallel with 15$\mu\mu$f; otherwise, the oscillator may be loaded enough to change its frequency slightly. Then, couple the 1 mc standard to the horizontal input and adjust the XTAL ADJ for a Lissajous pattern indicating equal frequencies.

The oscillator can also be adjusted by use of the Beckman/Berkeley Model 905 WWV Receiver. With the TIME switch at 10^{-6} the oscillator frequency appears at the time jack in the form of a shaped signal which contains harmonics up to the tenth and beyond. Couple a coaxial cable to this jack and place an exposed portion of the center conductor near the antenna terminals of the receiver. Tune the receiver to a WWV standard frequency (either 2.5, 5, 10 or 15 mc). Then, adjust the XTAL ADJ control until a harmonic of the oscillator frequency comes to zero beat with WWV, as indicated by a beat frequency tone.

NOTE

Whenever the oscillator crystal is replaced, it may be necessary to change capacitor C404 so that the frequency of oscillation can be adjusted to the correct value.

3.1.3 How to Adjust the Shaper Trigger Level. The shaper stage in the clockpulse generator is a voltage discriminator similar to those in the Input Trigger Channels. The SHAPER LEVEL control (R414) located on the top side of the counter chassis, sets the trigger voltage at the input to this circuit. To adjust, set the FUNCTION switch at TEST. Find the limits of the range of adjustment in which the instrument continues to count. Set the control at the center of this range.

3.1.4 How to Adjust the Frequency Dividers. If the instrument fails to produce correct count indications with the FUNCTION switch at TEST, one or more of the frequency dividers probably requires adjustment. The line voltage during adjustment should be either exactly 117v (in which case the adjustment will hold for line variations of ±10%) or the actual line voltage on which the instrument is to be operated.

The six adjusting controls are located in a line on top of the counter. Each should be adjusted while measuring the d-c voltage (with respect to ground) at the adjacent test jack. Rotate each control back and forth to the limits of the range within which a correct count indication appears, noting the test jack voltage at each such limit. Then, position the control so that the test jack voltage is midway between these limits. Follow the steps outlined in table 1 in the order listed there.

For example, with the TIME switch at 10^{-5} rotate the ADJ 10^{-5} SEC control slowly clockwise until the count indication changes from a correct indication (99, 100 or 101) to a high indication (109, 110 or 111). As the reading changes, the voltage at test jack E5 might be 87v. Now rotate the control counter-clockwise until the reading changes from a correct indication to a low indication (89, 90 or 91). The test jack voltage at this time might be 99v. Having found these voltages, you would position the control so that the voltage at the jack is 93v, a value midway between 87v and 99v.

3.1.5 How to Adjust the Time Trigger Level. The time trigger level has initially been set at the factory and should normally require no readjustment unless the Time Pulse Trigger tube (V670) is changed. This adjustment should, however, be checked if the instrument does not count properly at some of the TIME switch settings but does at others. To make the adjustment, proceed as follows:

Set the TIME switch to "10^{-5}", and observe the Time Pulse Trigger output (V670, pin 1) on an oscilloscope. Adjust the TIME TRIGGER LEVEL potentiometer (R682) for an interval of 1μs between a negative pulse and the positive pulse which immediately follows it. Now, set the FUNCTION switch to TEST and the TIME switch to "10^{-6}", and see if the instrument counts properly. If it does not, readjust R682 slightly.

3.1.6 How to Adjust the E Channel Trigger Level. The E channel trigger level has initially been set at the factory and should normally require no readjustment unless the Shaper tube (V702) is changed. This adjustment should, however, be checked if the sensitivity of the E input channel begins to decrease. To make the adjustment, proceed as follows:

With the E ATTENUATION control set at "1", feed in a sinewave signal having a frequency of 1 to 10 mc and a peak-to-peak amplitude of 300 mv. Set the E CHANNEL TRIGGER LEVEL potentiometer (R715) to the midpoint of the arc over which the instrument counts properly. Now reduce the amplitude of the input signal to the point at which the unit is just barely counting correctly and again adjust R715 as before. Continue to reduce the input signal and to readjust R715 until any further decrease immediately produces improper counting.

As a final check for proper adjustment, bring the input signal back up to 300 mv, reduce the frequency to about 10 cps, and see if the instrument counts properly.

Table 1.

	Place TIME switch at	Measure voltage at	Adjust this control	Count Indication		
				Low (Dividing by 9)	Correct (Dividing by 10)	High (Dividing by 11)
Step 1	10^{-5}	E5	10^{-5}SEC	89 90 91	99 100 101	109 110 111
Step 2	10^{-4}	E4	10^{-4}SEC	899 900 901	999 1000 1001	1099 1100 1101
Step 3	10^{-3}	E3	10^{-3}SEC	8,999 9,000 9,001	9,999 10,000 10,001	10,999 11,000 11,001
Step 4	10^{-2}	E2	10^{-2}SEC	89,999 90,000 90,000	99,999 100,000 100,001	109,999 110,000 110,001
Step 5	10^{-1}	E1	10^{-1}SEC	899,999 900,000 900,001	999,999 1,000,000 1,000,001	1,099,999 1,100,000 1,100,001
Step 6	1	E0	1 SEC	8,999,999 9,000,000 9,000,001	9,999,999 0,000,000 0,000,001	0,999,999 1,000,000 1,000,001

Modifications

Modified instruments are identified by a letter or letters after the model number. For example, the Model 7150D is a standard Model 7150 EPUT® Meter modified as described below under "Modification D". An instrument may be modified in more ways than one; for instance, the Model 7150DK is a Model 7150 changed in accordance with both "Modification D" and "Modification K".

MODIFICATION B

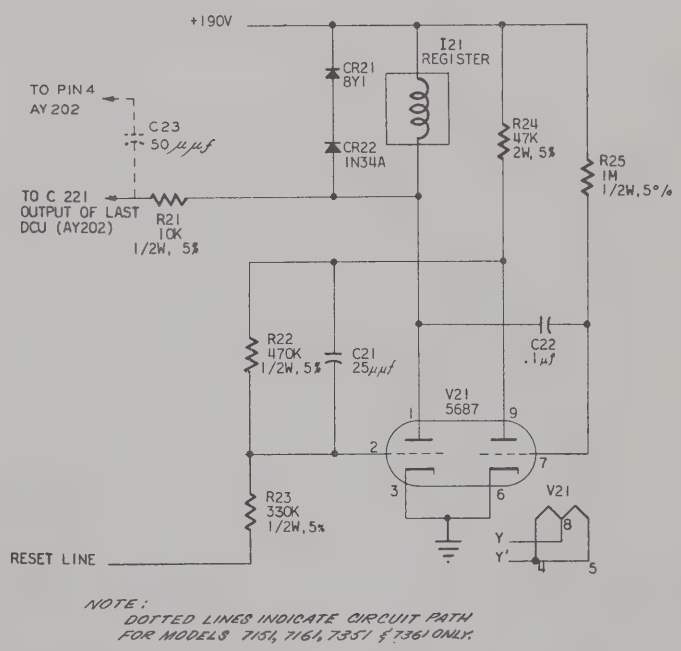
This consists of adding a dual-purpose decimal counting unit to 7000 series instruments which do not normally contain such a unit. Depending on the position of the FUNCTION switch, this DCU either extends the count capacity by a factor of 10 or divides the frequency of the pulses which start and stop counting by 10.

MODIFICATION C

This consists of the addition of a mechanical register which will extend the counting capacity of any 7000 series instrument by a factor of 10^3. Instead of using the electronic signal which resets the DCU's, the register is reset by a small lever on the front panel directly below the mechanical count-indicating dials.

On instruments with "X10" positions on the FUNCTION switch, the indicating panel of the DCU Divider (AY201) is not exposed to view when the C modification is made. The digit normally displayed by AY201 is shown at the right-hand digit of the register dial. AY202, the last exposed DCU next to the register, drives V21, a one-shot multivibrator. Each time this is activated a count is recorded on the mechanical register, the coil of which is the multivibrator plate load.

When AY202 resets, a counting pulse may appear in the output. To counteract this, the reset line is connected to control-grid pin 2 of V21, so that whenever a reset pulse causes a count from AY202 to appear on the plate pin 1 of V21, the reset pulse also appears at the grid. The two pulses, opposite in polarity, counteract each other so that no count is recorded at the register.

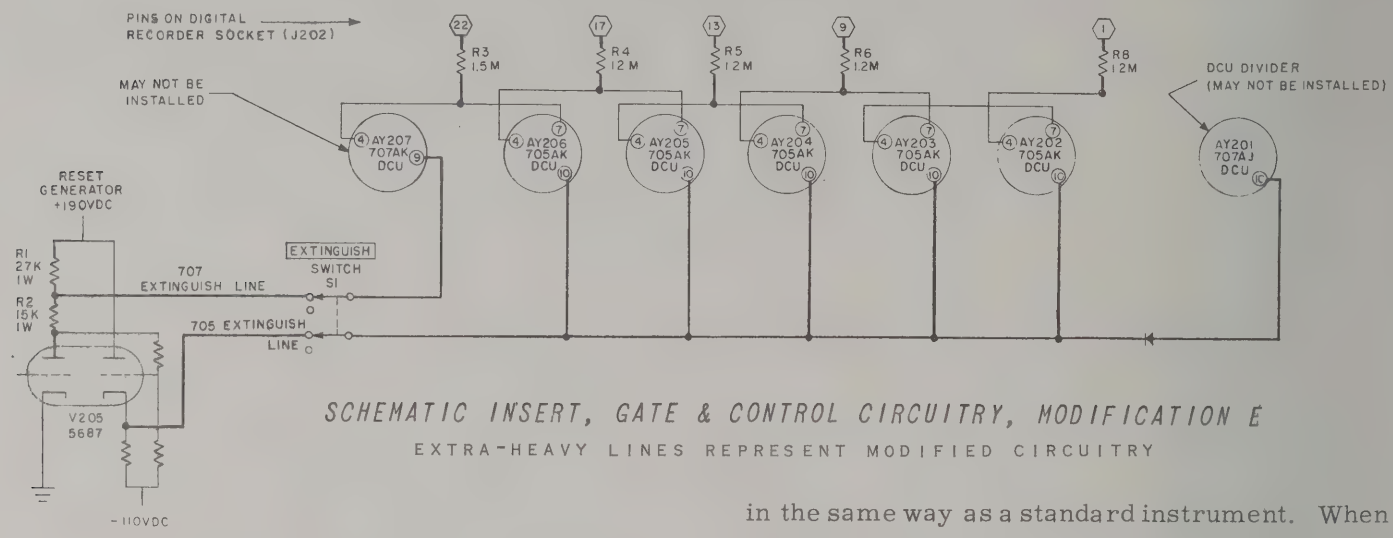


SCHEMATIC INSERT, GATE & CONTROL CIRCUITRY, MODIFICATION C

MODIFICATION D

This consists of substituting a 100Kcs heated crystal in the oscillator of the clock-pulse generator in place of a 100Kcs unheated crystal. This modification is applicable only to 7000 Series instruments which normally contain an unheated crystal (for example, Models 7150 and 7250). The heated crystal has a stability of 1 part in 10^6 per day as compared with a stability of 1 part in 10^5 per day for the unheated crystal.

MODIFICATION E



SCHEMATIC INSERT, GATE & CONTROL CIRCUITRY, MODIFICATION E

EXTRA-HEAVY LINES REPRESENT MODIFIED CIRCUITRY

This consists of replacing the standard decimal counting units with DCU's whose indicating bulbs can be extinguished automatically while the instrument is actively counting. With automatic extinguishing, the indicating bulbs light only at the end of each counting period to display the result.

The accompaning schematic insert shows how the circuitry of the standard instrument is modified. The voltage which extinguishes the DCU bulbs is supplied by the reset generator while it functions as usual in the standard automatic operating cycle. Both "extinguish lines" leading from the reset generator are at a relatively negative voltage at all times except during the display period. The relatively-negative voltage applied to the DCU's prevents the neon bulbs from lighting. The relatively-positive voltage on the "extinguish lines" during the display period permits the bulbs to light.

The EXTINGUISH toggle switch is located on top of the counter chassis. It may be exposed by lifting the top lid of the instrument. When this switch is closed the indicating bulbs are automatically extinguished as described above. When the switch is open the counter operates in the same way as a standard instrument. When counting is controlled manually (that is, by moving the FUNCTION switch from OFF to COUNT and back again) the EXTINGUISH switch should be open. Under manual control no automatic display period occurs, so the reset generator always supplies a voltage which would extinguish the indicating neons if connected to the DCU's.

All 705AH DCU's in the standard instrument are replaced by 705AK DCU's. Pin 10 of the DCU socket is connected to an "extinguish line" instead of to a pin in the DIGITAL RECORDER socket. The DIGITAL RECORDER pin which ordinarily connects to pin 10 is connected instead to pin 4 through a 1.2 megohm resistor.

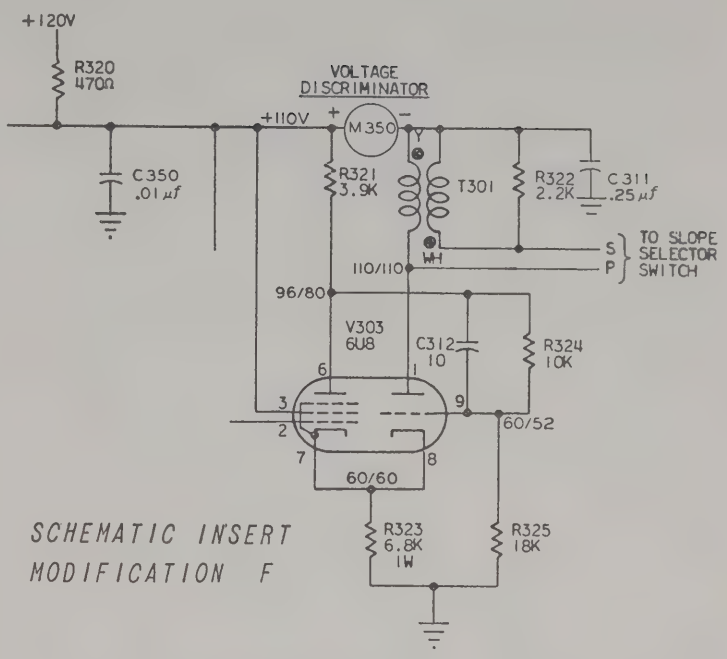
If the standard instrument has a maximum counting rate of 1 Mcs, it contains a 707AH DCU. This DCU is replaced by a 707AK DCU. An "extinguish line" is connected to pin 9 of the DCU socket, and the DIGITAL RECORDER pin which is ordinarily connected to pin 9 is connected instead to pin 4 through a 1.5 megohm resistor.

If the standard instrument is equipped with a DCU used as both a counter and a frequency divider (Model 705AJ), an "extinguish line" is connected to pin 10 of its socket.

MODIFICATION F

This consists of making modifications B, D and R plus adding a TRIGGER STATE meter to the E/UT input channel. The meter aids in adjusting the TRIGGER VOLTAGE control. The operator should adjust this control until the meter pointer stays in the center green region.

The TRIGGER STATE meter actually indicates the plate current flowing in the output triode of the voltage discriminator in the E/UT channel. This stage has two stable states: cut-off and conducting heavily. When the triode is cut-off, the meter indicates zero; when it is conducting, the meter is deflected to approximately full scale. The triode is triggered from one state to the other and back again by each input signal cycle. If the input frequency is above 10 cps the inertia of the meter will cause it to indicate the average plate current. A meter reading in the center green region indicates that the triode is cut-off half the time and conducting the other half. Under these conditions the channel produces the most reliable pulse output to be counted on the DCU's.

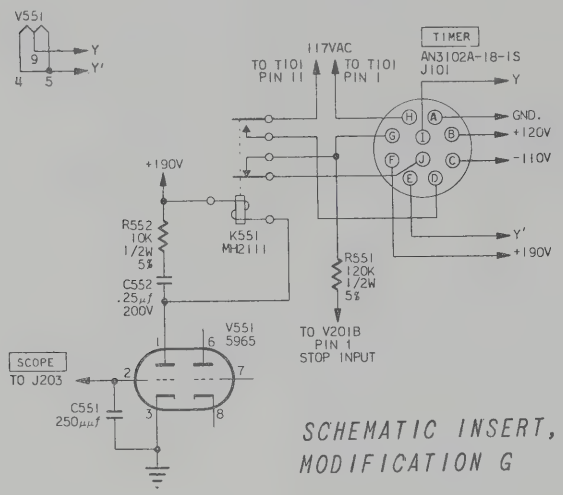


SCHEMATIC INSERT
MODIFICATION F

MODIFICATION G

This modification provides connections so that an external timer can be used to extend the sampling time of the counter. The labeling of J101 is changed from "ACCESSORY" to "TIMER". This socket provides 117 volt ac for operating the timer motor and it provides ground and Control Binary stop-input pin connections to the time-delay switch in the timer.

The G Modification functions with a timer in this manner. The timer dial is set to indicate a certain

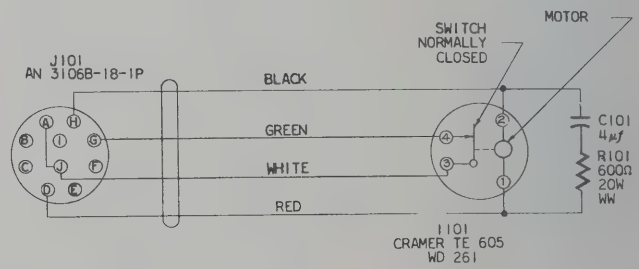


SCHEMATIC INSERT, MODIFICATION G

interval of time. A switch in the timer grounds the stop-input pin (pin 1, V201B) of the Control Binary (V203), so that once the counter starts counting it will not stop until the stop-input pin is ungrounded. The Relay Control tube (V501) conducts and energizes relay K501 when the Signal Gate (V204) "opens". (V501 is caused to start and stop conducting by the same signals that "open" and "close" the Signal Gate--that is, the output of the Control Binary.) When the relay energizes, it closes the contacts which supply 117 volts ac to energize the timer motor. After the pre-determined time interval, the time switch opens, and the Control Binary stop-input pin is removed from ground. The next clock pulse causes the Control Binary to "close" the Signal Gate and cut off the Relay Control tube (V501). K501 is de-energized, its contacts open and remove the power from the timer motor. At this point, the timer resets.

When the external timer is not used, remove the cable from the TIMER socket and the counter will operate normally.

The modified instrument is designed to be used with the Model 806 Timer. The timer will extend the 10-second automatic counting period to 20, 30, 40, 50 or 60 seconds. To install, simply connect timer plug to the TIMER socket at the rear of the counter. When operating, be sure the counter is set up to generate 10-second automatic counting period; that is, with the FUNCTION switch at E/UT x 10 and the TIME switch at "1". Set the timer to approximately 5 seconds less than the total counting period desired. Adjust the counter display time to one second or longer. If you find occasion to reset the instrument manually before the expiration of the extended counting period, depress the RESET button repeatedly until you see that the running pointer has returned to its starting position.

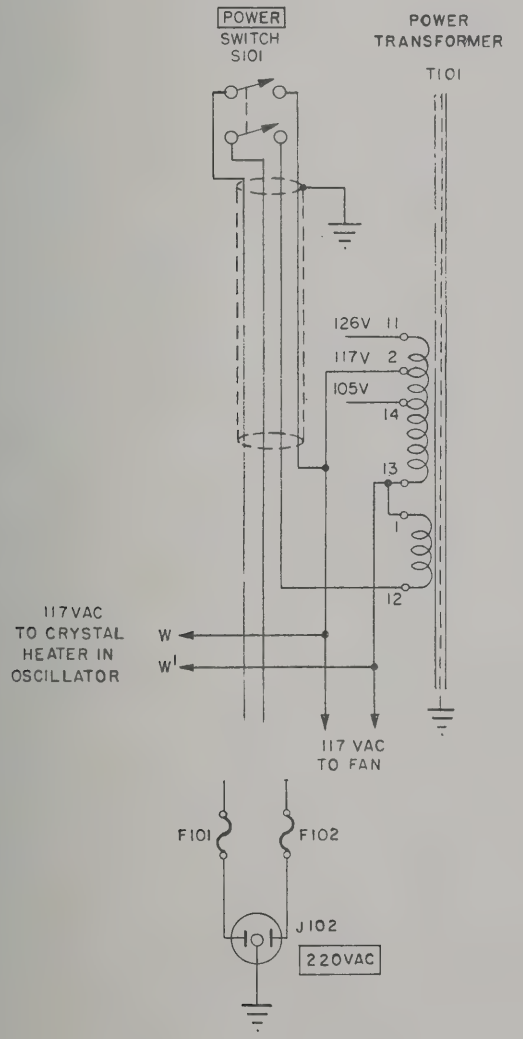


TIMER SCHEMATIC
DWG. NO. 806 A 1

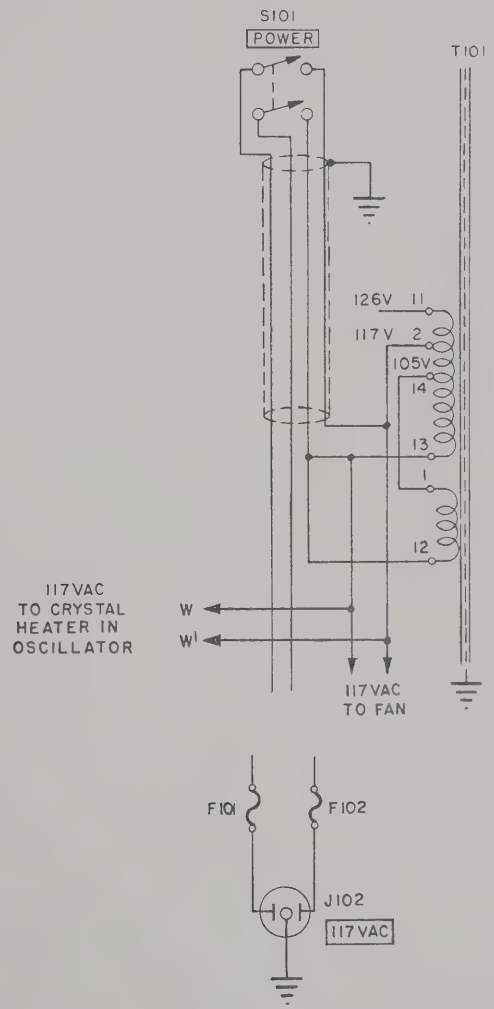
MODIFICATION H

This consists of modifying the instrument so it can be operated off a 220-volt line. The standard 117-volt power transformer is replaced by transformer having two primary windings, a 117-volt winding and a 105-volt winding. As shipped, these windings are connected in series so that when the instrument is connected to a 220-volt line, the proper voltage appears across each winding. The schematic insert below shows the modified circuitry. The line fuses (F101 & F102) in the standard counter have been replaced by fuses of one-half the standard current rating. Note that the crystal oven in the oscillator will no longer begin heating as soon as the instrument is plugged in, but will heat only when the POWER switch is on.

An instrument modified to operate on 220 volts can be reconverted to operate on 117 volts by changing the connections to the primary of the power transformer (T101) and replacing the line fuses. To do this break the connection between transformer terminals 1 and 13 and connect terminal 1 to terminal 14 and terminal 13 to terminal 12. Replace line fuses F101 and F102 with fuses of twice the current rating of those installed. The resulting circuitry is shown in the schematic insert below. Note that the 117-volt winding is connected across the line and that the 105-volt winding is connected in parallel with part of the 117-volt winding.



SCHEMATIC INSERT, POWER SUPPLY, MODIFICATION H



SCHEMATIC INSERT, POWER SUPPLY, MODIFICATION H RECONVERTED TO OPERATE ON 117 VOLTS AC.

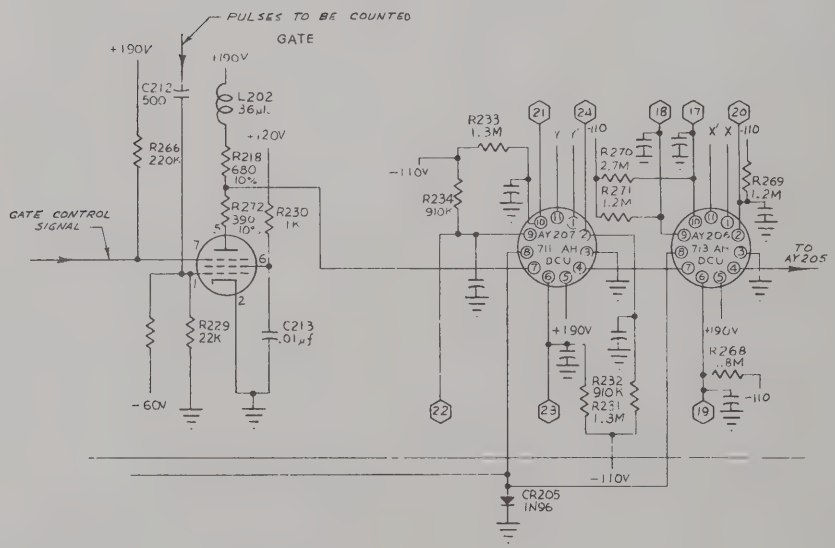
MODIFICATION J

The purpose of this modification is to increase the maximum counting rate from 1Mcs to 2Mcs. To do this the first two DCU's in the counting chain are replaced with higher speed units and both input channels are modified to extend the frequency range of each to 2Mcs.

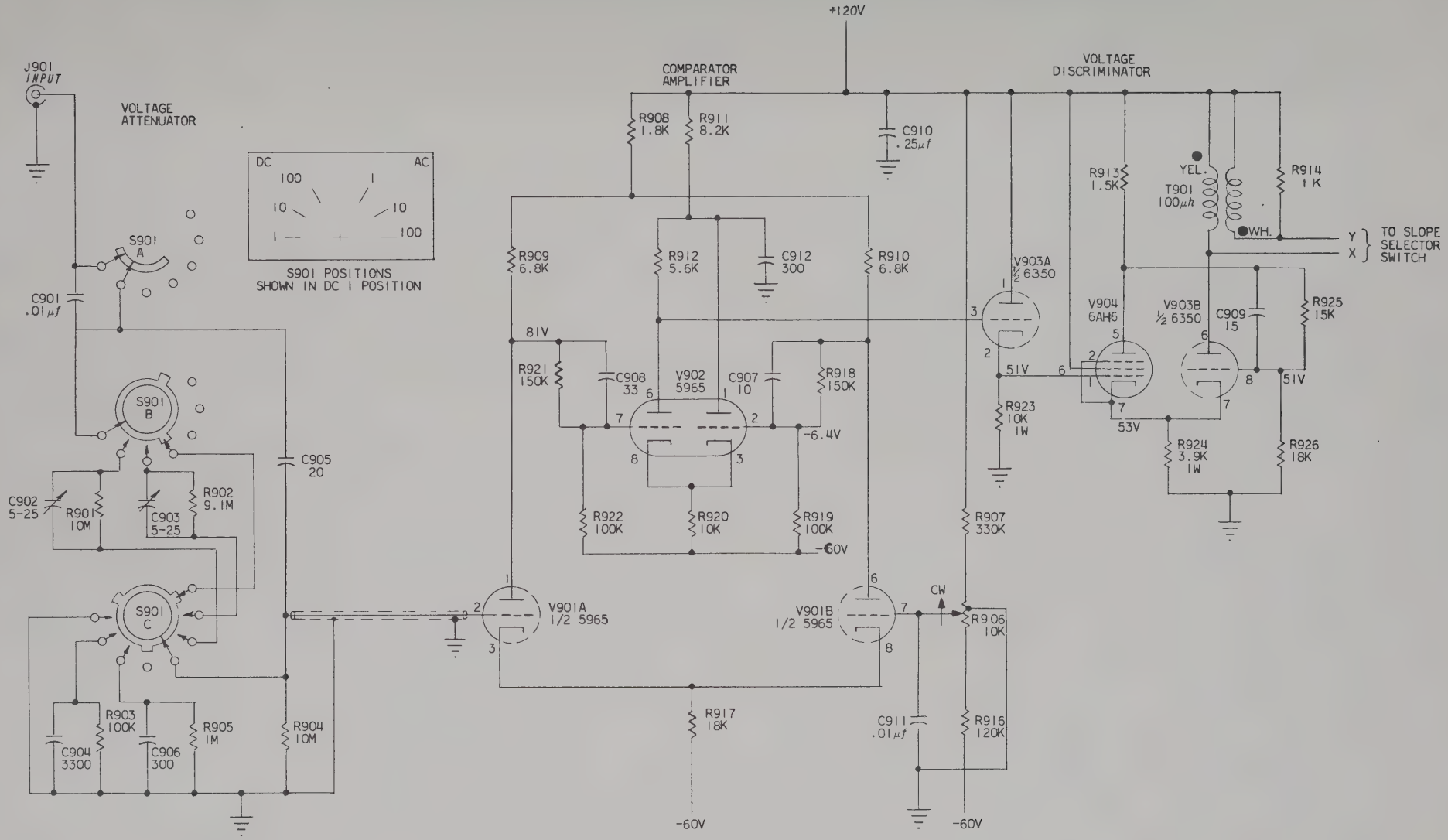
The new DCU's are the Model 711AH, which replaces a Model 707AH as AY207, and the Model 713AH, which replaces a Model 705AH as AY206. Instruction manuals on the new DCU's are located at the rear of this booklet. To accomodate this change, the circuitry surrounding the new DCU's and the gate circuitry is modified slightly, as shown in the accompanying schematic insert.

The frequency response of the input channels has been extended by inserting a cathode follower between the difference amplifier and the voltage discriminator. A schematic diagram of the modified channel appears on the following page.

(NOTE: On the Model 7360 Universal EPUT® and Timer, this modification includes the addition of an accessory socket as described under "MODIFICATION U".)



'SCHEMATIC INSERT, GATE & CONTROL CIRCUITRY
MODIFICATION J



NOTE:

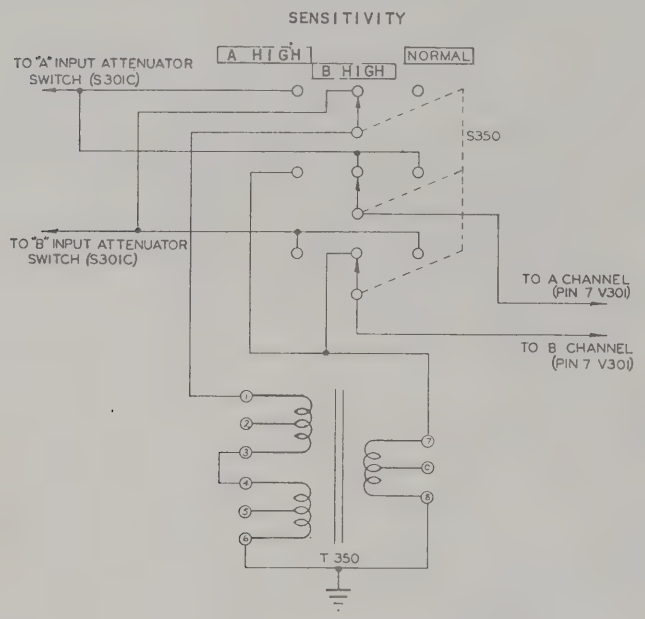
RESISTORS: 1/2 WATT, 5% UNLESS OTHERWISE NOTED.

CAPACITORS: IN μμf UNLESS OTHERWISE NOTED.

SCHEMATIC DIAGRAM
INPUT TRIGGER CHANNEL
MODIFICATION J.
DWG NO. 5571C7

MODIFICATION K

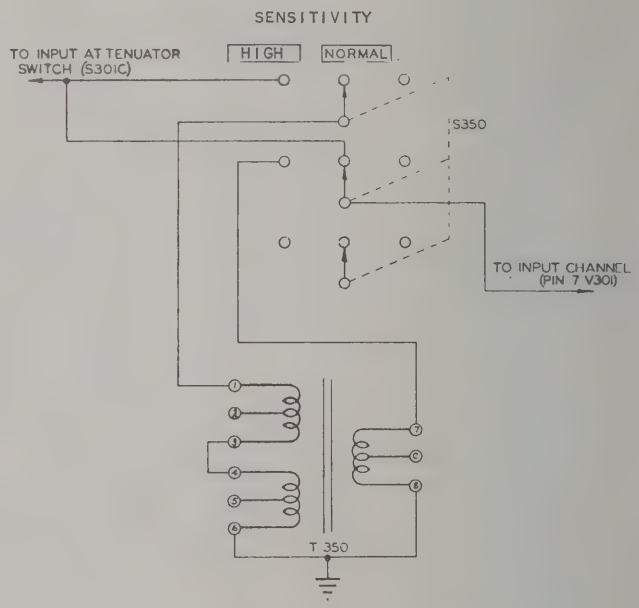
The purpose of this modification is to increase the input sensitivity of the counter from 100mv rms to 5mv rms with a resultant decrease in input impedance. This is done by adding a step-up transformer in the input circuit. The operator may insert and remove the transformer by positioning a front-panel sensitivity switch.



WIRING FOR TWO INPUT CHANNELS

If the modified instrument has two input channels, the front-panel switch will have three positions marked "NORMAL", "A HIGH" and "B HIGH". At NORMAL the transformer is not connected to either input channel, and the instrument functions just as though it had not been modified. At A HIGH the step-up transformer is connected between the attenuator and the input grid of the A channel. At B HIGH the transformer is inserted between the B attenuator and the input grid of that channel. If the modified instrument contains only one input channel the front-panel switch has only two positions; one marked "NORMAL", the other marked "HIGH".

Do not insert the transformer in an input channel unless the input signal is below the normal sensitivity of the counter. With the transformer connected, the ATTENUATION control should be at DC-1. Under these conditions the input impedance will vary with frequency, rising from at least 300 ohms at 5cps to approximately 25K ohms at 10Kcs. Sensitivity is at least 5mv over this frequency range.



WIRING FOR ONE INPUT CHANNEL

MODIFICATION L

This modification makes it possible to set the digital divider number (N) on a preset counter (Model 7151, 7161, 7351, or 7361) either at the front panel of the instrument or at a remote point. The modification includes the following changes made in a standard instrument.

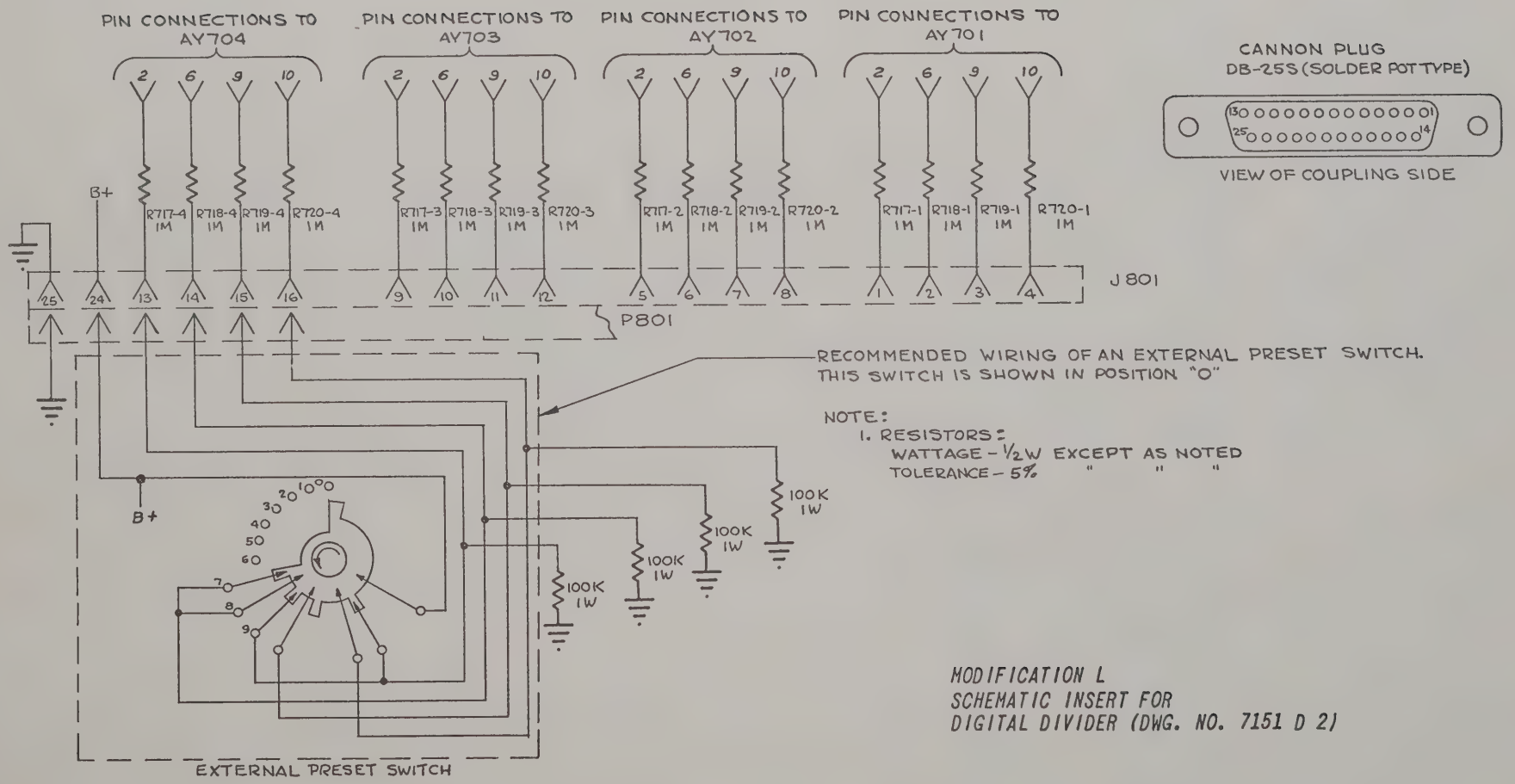
A 25-pin female connector (J801) has been added on the rear of the chassis. This connector is wired to the sockets of the digital divider DCU's as shown on the schematic insert for this modification.

One end of a length of ribbon cable has been wired to the preset switches mounted on the instrument. The other end of this cable, terminated by a 25-pin male connector (P801), extends from the rear of the unit and plugs into the chassis connector.

Another 25-pin male connector is provided for wiring to the external preset switches (see schematic insert).

To control the digital divider from the remote preset switches, unplug the ribbon cable connector at the right rear of the chassis and plug in the connector wired to the remote unit. To return control of the divider to the front panel thumbswitches, merely reverse the procedure.

See following page for schematic diagram.



CANNON PLUG
DB-25S (SOLDER POT TYPE)

VIEW OF COUPLING SIDE

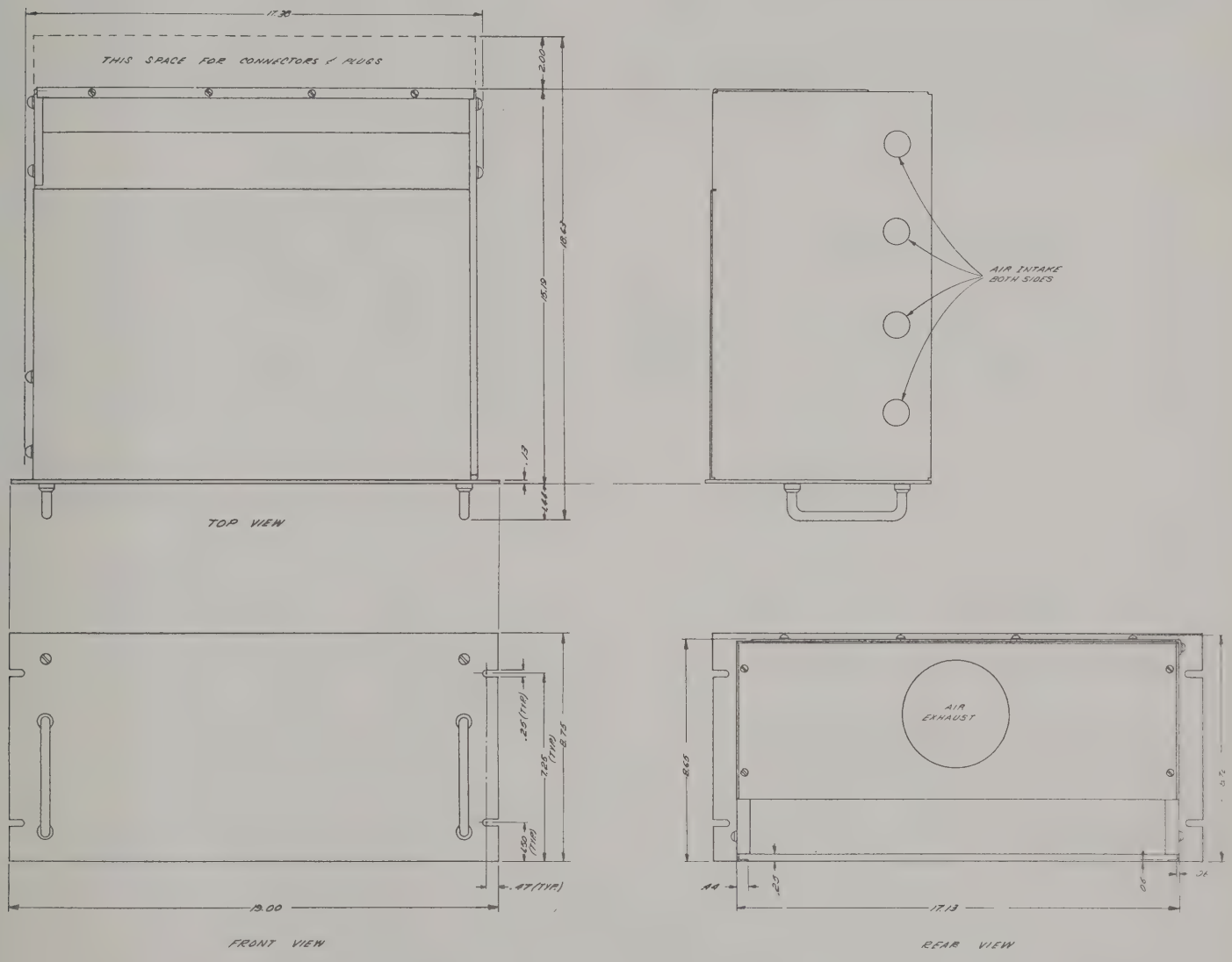
NOTE:
1. RESISTORS:
WATTAGE – ½W EXCEPT AS NOTED
TOLERANCE – 5% " " "

MODIFICATION L
SCHEMATIC INSERT FOR
DIGITAL DIVIDER (DWG. NO. 7151 D 2)

MODIFICATION R

In this modification, the instrument is supplied without a cabinet but with a dust cover on top of the chassis. This allows the unit to be installed and operated in a standard relay rack. Mounting dimensions are as shown in the figure below.

Cooling air is drawn into the unit through a set of intake ports near the bottom of both sides of the chassis. These should remain relatively unobstructed to allow a free flow of air. The same holds true for the exhaust opening in the back of the unit.



RACK MOUNTING DIMENSIONS, MODIFICATION R

MODIFICATION T

This consists of the V modification plus a half-second clock-pulse interval in place of the usual one-second interval. The last stage of the Frequency Divider Chain is modified from a divide-by-ten to a divide-by-five stage. This is done by changing the value of timing capacitor C617 from 0.47μfd to 0.25μfd. The extreme clockwise position of the TIME-SECONDS switch is also changed to read ".5". When using an instrument with this modification keep in mind that the maximum sampling time available is 0.5 seconds, not 1.0 seconds.

MODIFICATION U

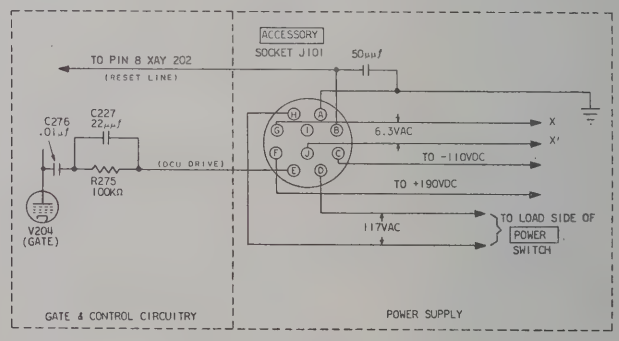
This consists of adding an accessory socket to the rear panel. The socket carries ac and dc voltages which can be used to power auxiliary equipment.

Pin No.	Voltage
A	Ground
B	+120v dc reg.
C	-110v dc unreg.
D	Spare
E	6.3v ac (gnd. side)
F	+200v dc unreg.
G	Spare
H	Spare
I	6.3v ac (hot side)
J	Spare

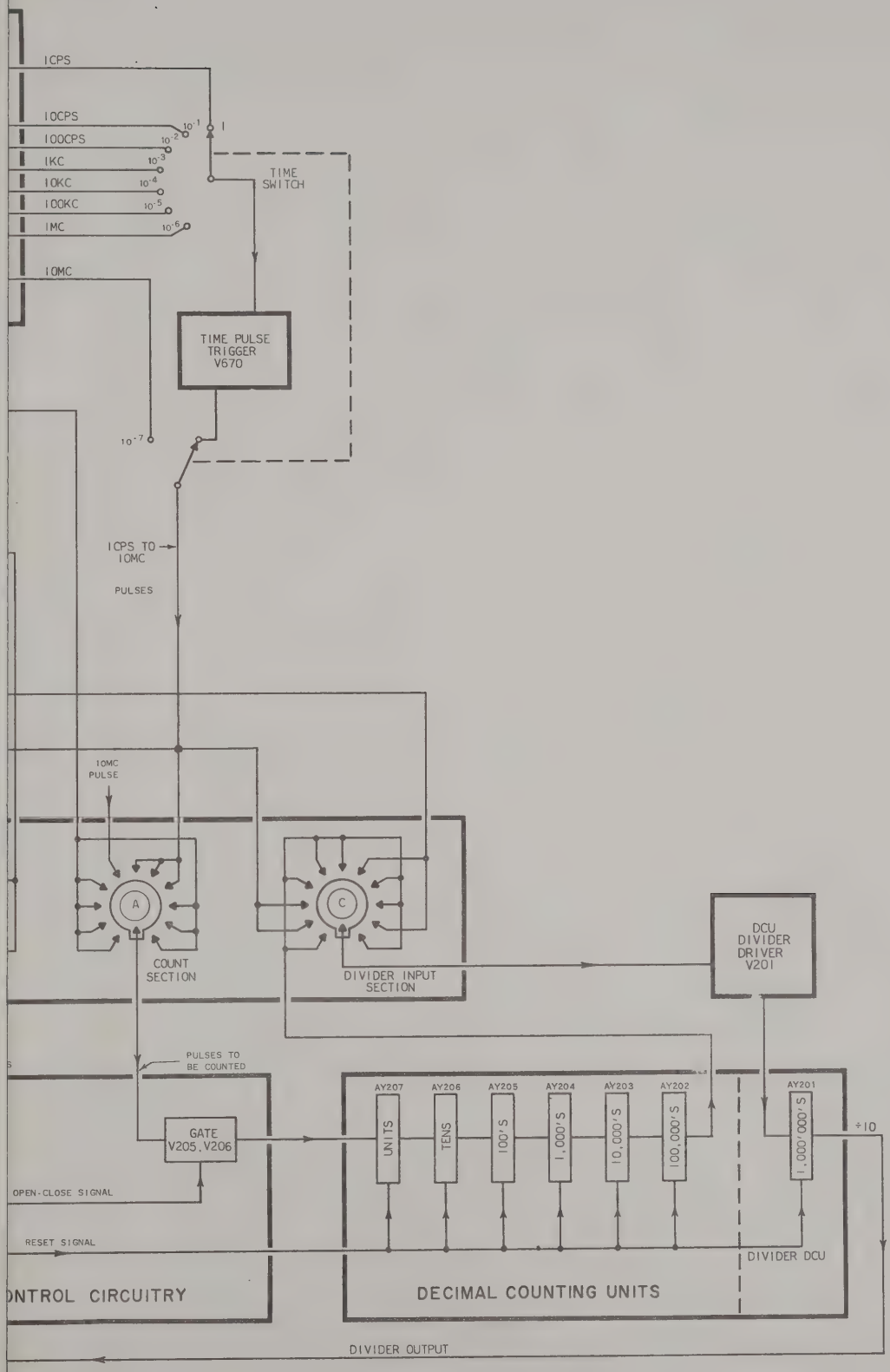
MODIFICATION V

The V modification provides DCU Drive and Reset signals, as well as power at the ACCESSORY socket (J101) for operating a remote indicator consisting of several cascaded DCU's. The DCU drive signal is taken from the plate of the Signal Gate (V204). The signal is passed through a network which reduces its amplitude and its output impedance before it reaches the ACCESSORY socket. The Reset signal is taken directly from the reset line (pin 8 of the DCU's). In addition, B+ and B- voltages are available at J101, as well as 117 volts ac to power a fan and a filament transformer.

The DCU's may be removed from the counting instrument and placed in the remote indicator. If this is done there will no longer be a signal at J202, the DIGITAL RECORDER socket, for operating an accessory recorder. With the remote indicator in use, operate the counting instrument in the usual manner. When the remote indicator is not used, disconnect the indicator cable from the ACCESSORY socket.

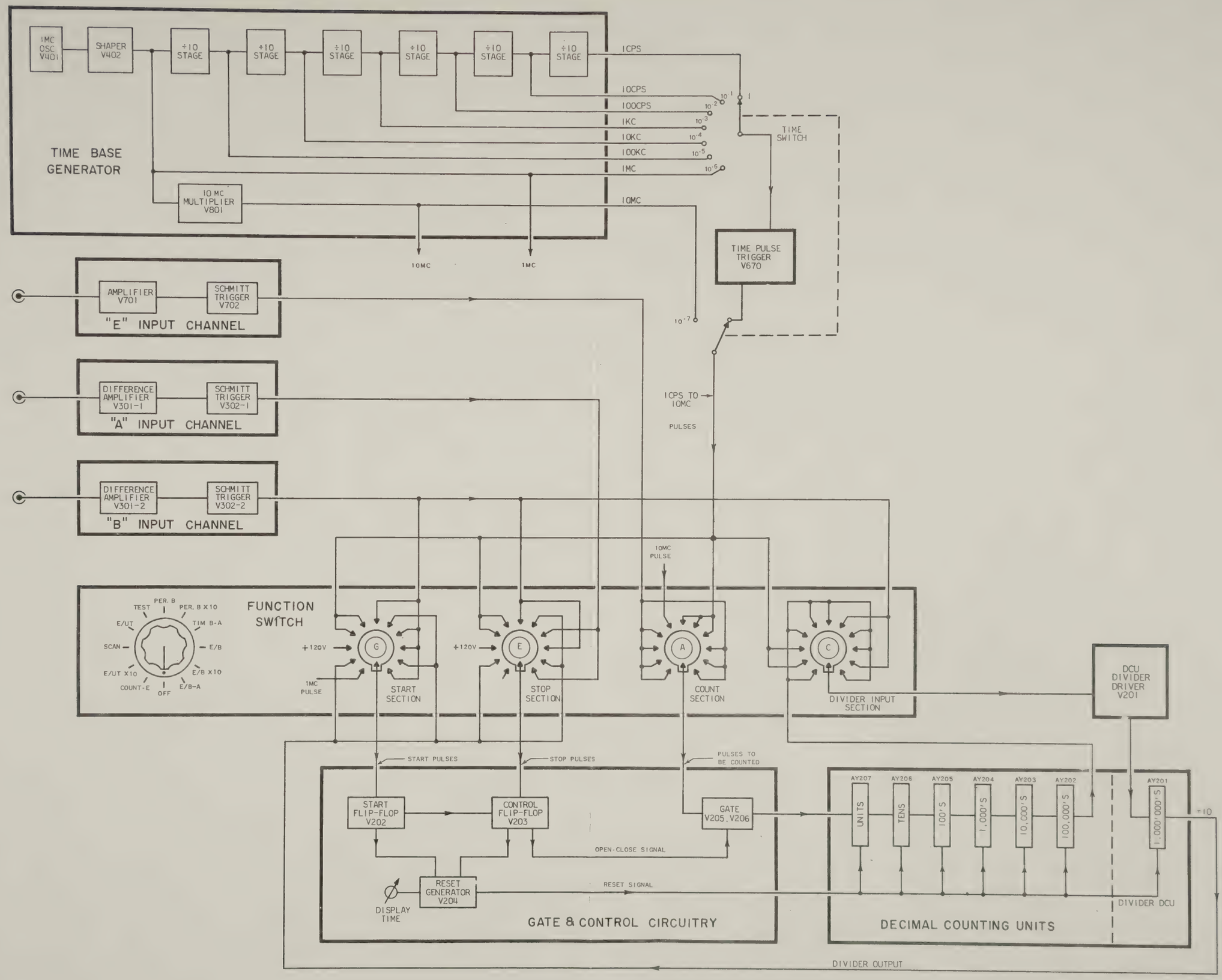


SCHEMATIC INSERT, MODIFICATION V



BLOCK DIAGRAM
MODEL 7370

June 1960



June 1960

BLOCK DIAGRAM
MODEL 7370

PARTS LIST, MASTER SCHEMATIC DIAGRAM

Refer to Dwg. No. 7370 D 200

NOTE

The following parts list includes all electrical components except fixed composition resistors whose value, rating, and tolerance are given on the schematic diagram.

ABBREVIATIONS

B/B	Beckman/Berkeley, Richmond, California
CD	Cornell-Dubilier Electric Corp., S. Plainfield, New Jersey
CH	Cutler-Hammer, Inc., Milwaukee, Wisconsin
GMV	Guaranteed Mimimum Value

Detail No.	Berkeley Stock No.	Description	Manufacturer & No.
C201	2-2137	Capacitor, mica, 500μμf, 300V, 5%	Sangamo RR1350
C202		Same as C201	
C203	2-3242	Capacitor, ceramic, .001μf, 600V, 10%	Erie GPL-1000
C204	2-7272	Capacitor, paper, 0.5μf, 200V, 20%	Hopkins P52DS
C205	2-2230	Capacitor, ceramic, .01μf, 450V	Erie 811-.01
C206	2-2608	Capacitor, mica, 300μμf, 500V, 5%	Sangamo RR1330
C207	2-2136	Capacitor, mica, 100μμf, 500V, 5%	Sangamo DR1310
C208	2-2082	Capacitor, mica, 10μμf, 500V, 5%	Sangamo RR1410
C209	2-5793	Capacitor, ceramic, .001μf, 1000V, 20%	Centralab DD102
C210		Same as C201	
C211 & C212		Same as C208	
C213		Same as C209	
C214		Same as C208	
C215		Same as C205	
C216	2-5583	Capacitor, paper, 0.5μf, 200V, +40% -20%	CD PJ2P5
C217		Same as C205	
C218		Same as C210	
C219	2-6492	Capacitor, ceramic, .02μf, 600V, GMV	Erie 817-.02
C220	2-2141	Capacitor, mica, 50μμf, 500V, 5%	Sangamo RR1450
C221	2-5467	Capacitor, mica, 75μμf, 500V, 5%	Sangamo RR1475
C222		Same as C201	
C223		Same as C219	
C225 thru C244		Same as C209	
C245		Same as C220	
C246	2-5691	Capacitor, paper, 0.1μf, 400V, 20%	Hopkins P14D
C247 thru C254		Same as C209	
C255		Same as C205	
C256	2-4388	Capacitor, ceramic, .01μf, 500V, +80% -20%	Sprague 29C9
C257		Same as C208	
CR201	8-7274	Diode, 1N198	Hughes
CR202	8-7183	Diode, CD1266	Continental Devices
CR203		Same as CR201	
CR204 thru CR206		Same as CR201	
CR207	8-4182	Diode, 6RSIGH3TM1	General Electric
CR208 thru CR210		Same as CR201	
CR211		Same as CR202	
CR212	8-5580	Diode, 1N95	Hughes
CR213		Same as CR212	
CR214 & CR215		Same as CR201	
CR216	8-7411	Diode, TI651C1	Texas Inst.
CR217		Same as CR207	
CR218		Same as CR201	
CR219		Same as CR207	
J202	17-5620	Connector, female, 40 pin	Cannon DPX-40-34S
J203	17-7712	Connector, tip jack	Whitso JNP-11
L201	3-4925	Inductor, 1.8μh	Wilco 208-110
L202	3-7044	Inductor, 25μh	Wilco 1025-15
L203 thru L205		Same as L202	
L206	3-5618	Inductor, 10μh	Wilco 217-118
L207	3-4861	Inductor, 4.7μh	Wilco 213-115
L208	3-4827	Inductor, 8.2μh	Wilco 216-117
L209	3-7251	Ferrite bead	Ferroxcube 255 T 118 A 205
L210 thru L214		Same as L209	
R243	1-7309	Potentiometer, 12M, 1/2W, 30% w/switch	Centralab Model "B"
S201	12-1641	Switch, toggle, SPDT	CH 8282K13
S202	12-1909	Switch, toggle, DPDT	CH8373K8
S203	12-8208	Switch, rotary	B/B
S204		p/o R243	
S205	12-0446	Switch, pushbutton, SPDT	Switchcraft 203
T201	6-5821	Transformer, Pulse, 1:1	B/B
T202		Same as T201	
V201	5-4764	Tube, 6922	
V202 thru V204		Same as V201	
V205	5-3521	Tube, 6AK5	
V206	5-0500	6AS6	
XV201	4-2973	Socket, 9 pin	Elco 377BC
XV202 thru XV204		Same as XV201	
XV205	4-2972	Socket, 7 pin	Elco 316BC
XV206		Same as XV205	
XA201	4-1720	Socket, 11pin,	Amphenol 77M1P11
XA202 thru XA207		Same as XA201	

PARTS LIST, MASTER SCHEMATIC DIAGRAM

Refer to Dwg. No. 7370 D 200

NOTE

The following parts list includes all electrical components except fixed composition resistors whose value, rating, and tolerance are given on the schematic diagram.

ABBREVIATIONS

B/B	Beckman/Berkeley, Richmond, California
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CH	Cutler-Hammer, Inc., Milwaukee, Wisconsin
GMV	Guaranteed Mimimum Value

Detail No.	Berkeley Stock No.	Description	Manufacturer & No.
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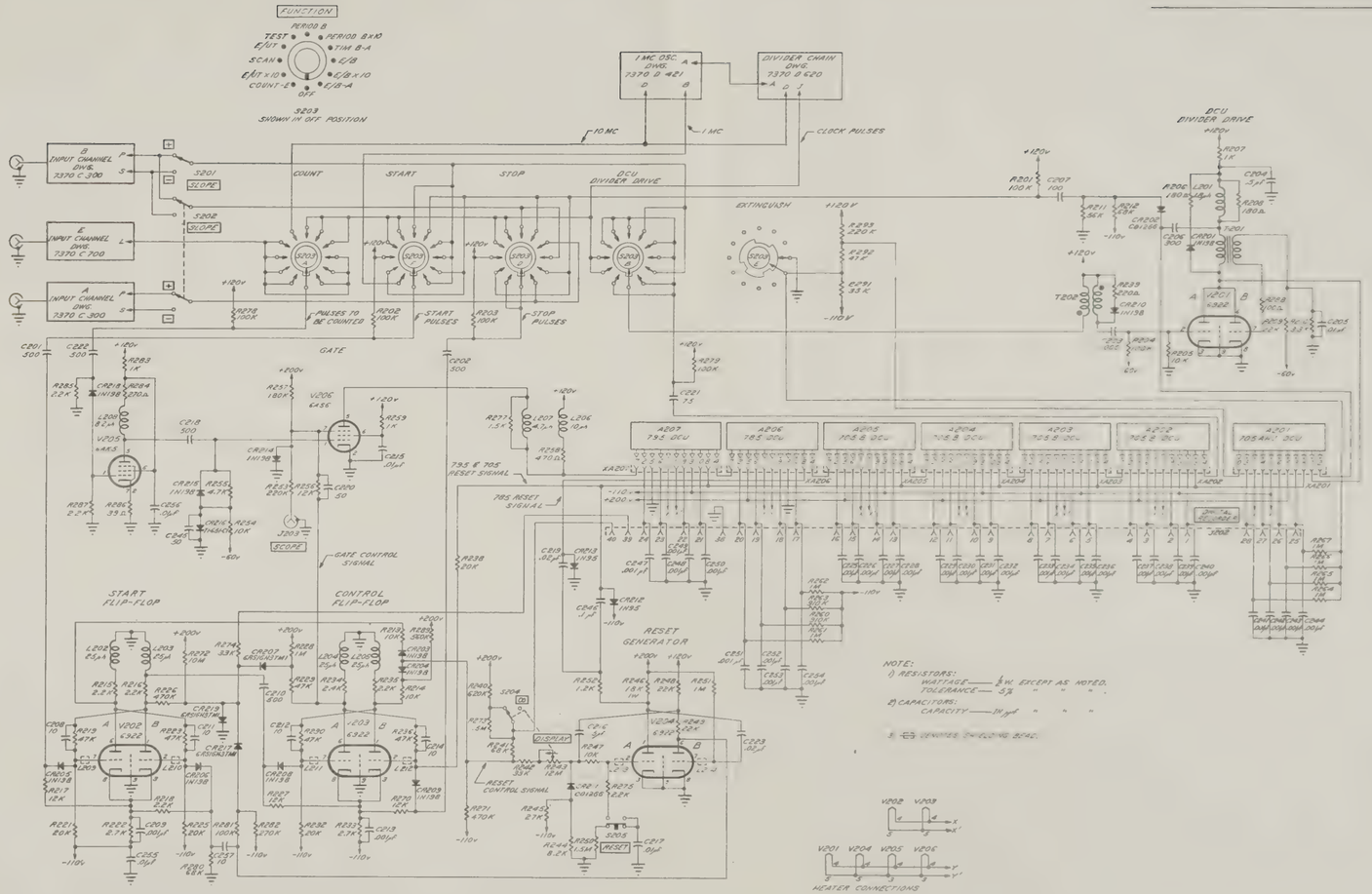
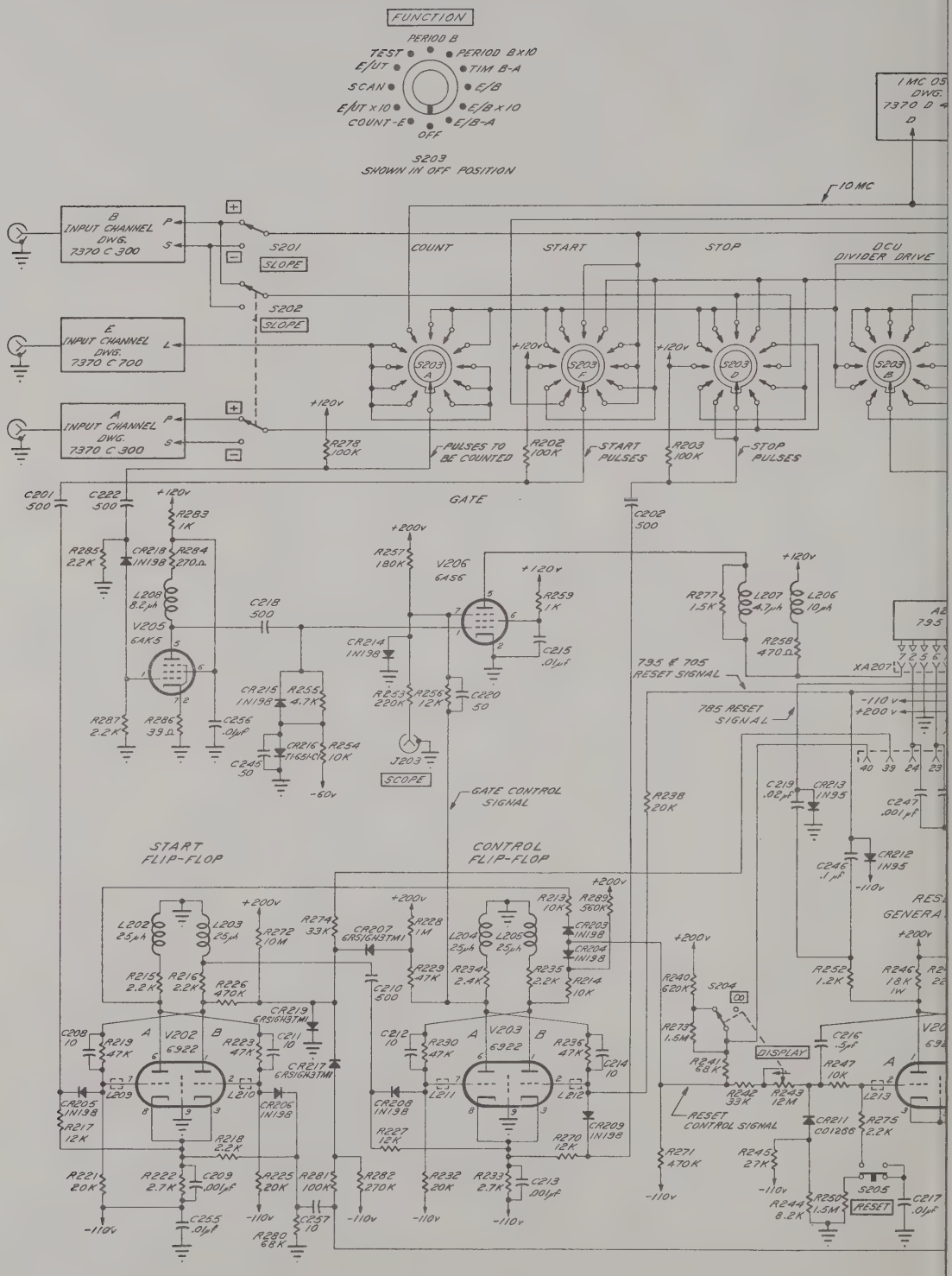
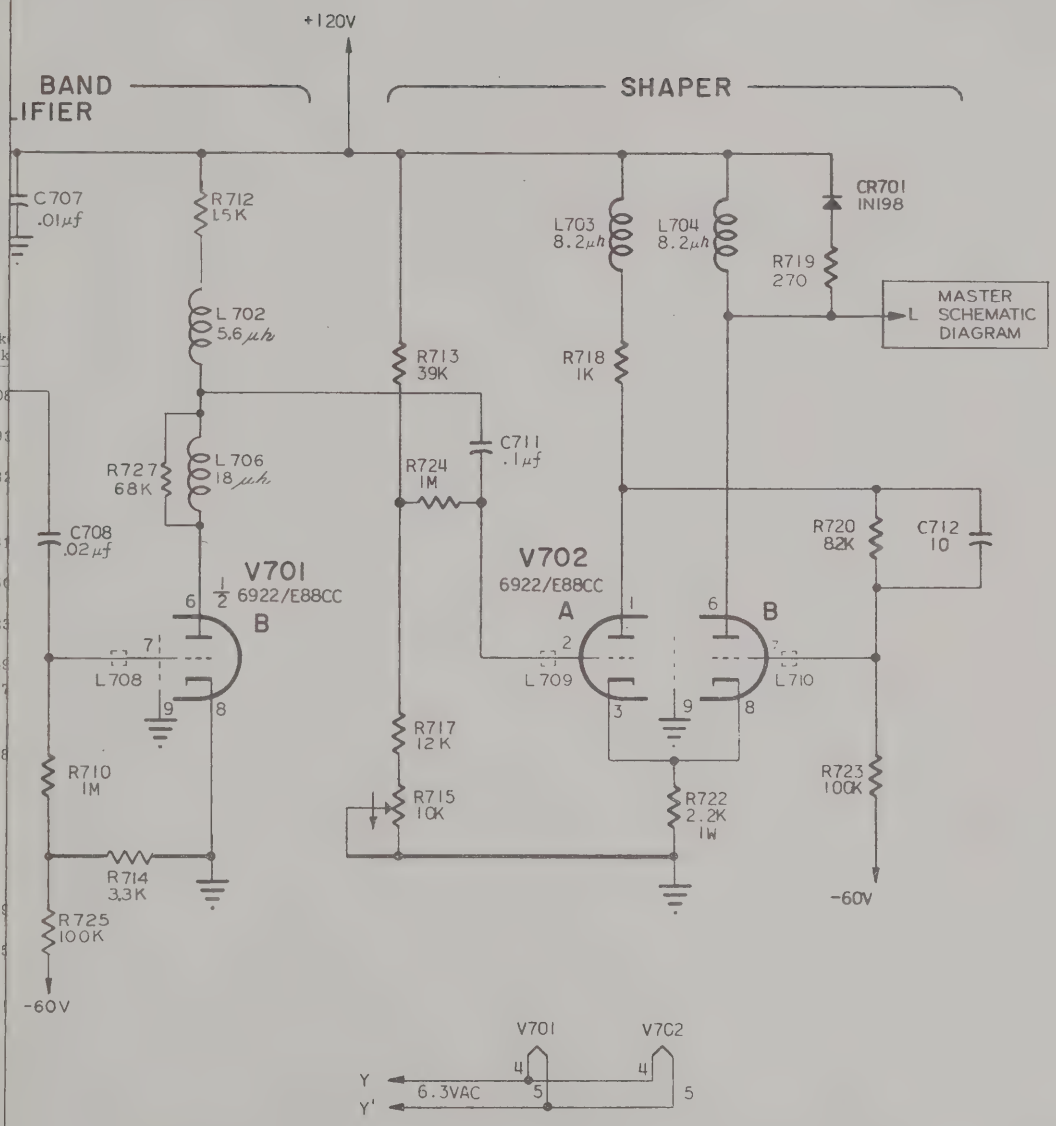
C202		Same as C201	
C203	2-3242	Capacitor, ceramic, .001μf, 600V, 10%	Erie GPL-1000
C204	2-7272	Capacitor, paper, 0.5μf, 200V, 20%	Hopkins P52DS
C205	2-2230	Capacitor, ceramic, .01μf, 450V	Erie 811-.01
C206	2-2608	Capacitor, mica, 300μμf, 500V, 5%	Sangamo RR1330
C207	2-2136	Capacitor, mica, 100μμf, 500V, 5%	Sangamo DR1310
C208	2-2082	Capacitor, mica, 10μμf, 500V, 5%	Sangamo RR1410
C209	2-5793	Capacitor, ceramic, .001μf, 1000V, 20%	Centralab DD102
C210		Same as C201	
C211 & C212		Same as C208	
C213		Same as C209	
C214		Same as C208	
C215		Same as C205	
C216	2-5583	Capacitor, paper, 0.5μf, 200V, +40% -20%	CD PJ2P5
C217		Same as C205	
C218		Same as C210	
C219	2-6492	Capacitor, ceramic, .02μf, 600V, GMV	Erie 817-.02
C220	2-2141	Capacitor, mica, 50μμf, 500V, 5%	Sangamo RR1450
C221	2-5467	Capacitor, mica, 75μμf, 500V, 5%	Sangamo RR1475
C222		Same as C201	
C223		Same as C219	
C225 thru C244		Same as C209	
C245		Same as C220	
C246	2-5691	Capacitor, paper, 0.1μf, 400V, 20%	Hopkins P14D
C247 thru C254		Same as C209	
C255		Same as C205	
C256	2-4388	Capacitor, ceramic, .01μf, 500V, +80% -20%	Sprague 29C9
C257		Same as C208	
CR201	8-7274	Diode, 1N198	Hughes
CR202	8-7183	Diode, CD1266	Continental Devices
CR203		Same as CR201	
CR204 thru CR206		Same as CR201	
CR207	8-4182	Diode, 6RSIGH3TM1	General Electric
CR208 thru CR210		Same as CR201	
CR211		Same as CR202	
CR212	8-5580	Diode, 1N95	Hughes
CR213		Same as CR212	
CR214 & CR215		Same as CR201	
CR216	8-7411	Diode, TI651C1	Texas Inst.
CR217		Same as CR207	
CR218		Same as CR201	
CR219		Same as CR207	
J202	17-5620	Connector, female, 40 pin	Cannon DPX-40-34S
J203	17-7712	Connector, tip jack	Whitso JNP-11
L201	3-4925	Inductor, 1.8μh	Wilco 208-110
L202	3-7044	Inductor, 25μh	Wilco 1025-15
L203 thru L205		Same as L202	
L206	3-5618	Inductor, 10μh	Wilco 217-118
L207	3-4861	Inductor, 4.7μh	Wilco 213-115
L208	3-4827	Inductor, 8.2μh	Wilco 216-117
L209	3-7251	Ferrite bead	Ferroxcube 255 T 118 A 205
L210 thru L214		Same as L209	
R243	1-7309	Potentiometer, 12M, 1/2W, 30% w/switch	Centralab Model "B"
S201	12-1641	Switch, toggle, SPDT	CH 8282K13
S202	12-1909	Switch, toggle, DPDT	CH8373K8
S203	12-8208	Switch, rotary	B/B
S204		p/o R243	
S205	12-0446	Switch, pushbutton, SPDT	Switchcraft 203
T201	6-5821	Transformer, Pulse, 1:1	B/B
T202		Same as T201	
V201	5-4764	Tube, 6922	
V202 thru V204		Same as V201	
V205	5-3521	Tube, 6AK5	
V206	5-0500	6AS6	
XV201	4-2973	Socket, 9 pin	Elco 377BC
XV202 thru XV204		Same as XV201	
XV205	4-2972	Socket, 7 pin	Elco 316BC
XV206		Same as XV205	
XA201	4-1720	Socket, 11pin,	Amphenol 77M1P11
XA202 thru XA207		Same as XA201	



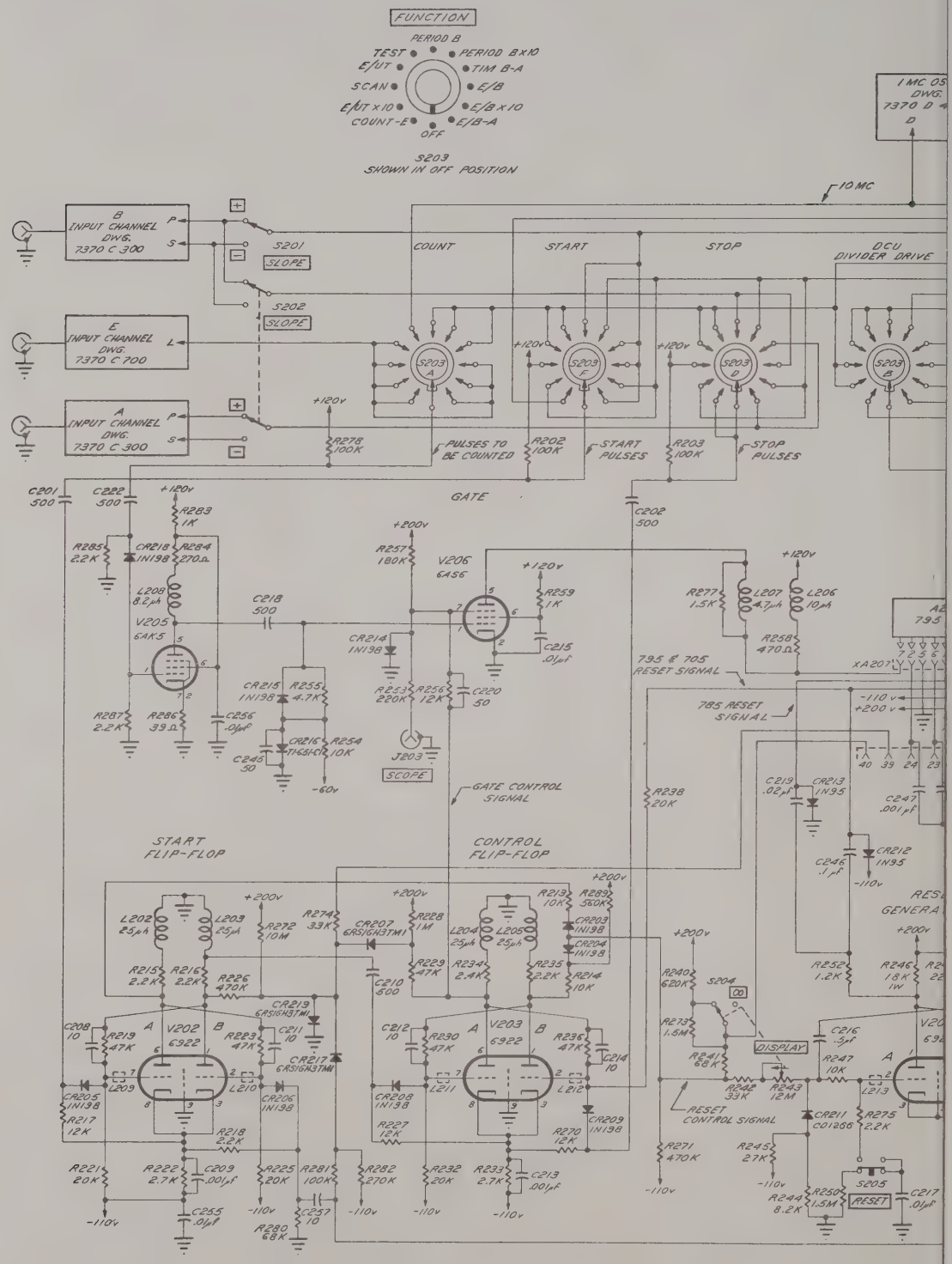
BECKMAN/BERKELEY DIVISION
DWG. NO. 7370 D 200


FUNCTION
PERIOD B
TEST
PERIOD B X10
E/UT
TIM B-A
SCAN
E/B
E/UT X10
E/B X10
COUNT-E
E/B-A
OFF
S203
SHOWN IN OFF POSITION
10 MC
B INPUT CHANNEL DWG. 7370 C 300
E INPUT CHANNEL DWG. 7370 C 700
A INPUT CHANNEL DWG. 7370 C 300
S201 SLOPE
S202 SLOPE
COUNT
START
STOP
DCU DIVIDER DRIVE
S203 A
S203 F
S203 D
S203 B
+120v
R278 100K
R202 100K
R203 100K
PULSES TO BE COUNTED
START PULSES
STOP PULSES
GATE
C201 500
C222 500
C202 500
R283 1K
R285 2.2K
CR218 IN198
R284 270Ω
L208 8.2μh
V205 6AK5
C218 500
R287 2.2K
R286 39Ω
C256 .01μf
CR215 IN198
R255 4.7K
CR216 TI651-CR
R254 10K
C245 50
-60v
+200v
R257 180K
V206 6AS6
R259 1K
C215 .01μf
CR214 IN198
R253 220K
R256 12K
C220 50
J203
SCOPE
GATE CONTROL SIGNAL
R277 1.5K
L207 4.7μh
L206 10μh
R258 470Ω
795 & 705 RESET SIGNAL
785 RESET SIGNAL
XA207
-110v
+200v
R238 20K
C219 .02μf
CR213 IN95
C247 .001μf
C246 .1μf
CR212 IN95
START FLIP-FLOP
CONTROL FLIP-FLOP
L202 25μh
L203 25μh
R272 10M
R274 33K
CR207 6RS1GH3TM1
R228 1M
R215 2.2K
R216 2.2K
R226 470K
R229 47K
C210 500
L204 25μh
L205 25μh
R213 10K
R289 560K
CR203 IN198
CR204 IN198
R234 2.4K
R235 2.2K
R214 10K
CR219 6RS1GH3TM1
C208 10
R219 47K
V202 6922
R223 47K
C211 10
CR217 6RS1GH3TM1
C212 10
R230 47K
V203 6922
R236 47K
C214 10
CR205 IN198
L209
L210
R217 12K
CR206 IN198
CR208 IN198
L211
L212
CR209 IN198
R227 12K
R270 12K
R218 2.2K
R221 20K
R222 2.7K
C209 .001μf
C255 .01μf
R225 20K
R281 100K
C257 10
R280 68K
R282 270K
R232 20K
R233 2.7K
C213 .001μf
-110v
R240 620K
S204
R273 1.5M
R241 68K
DISPLAY
C216 .5μf
R247 10K
R242 33K
R243 12M
RESET CONTROL SIGNAL
CR211 CD1266
L213
R275 2.2K
R271 470K
R245 27K
R244 8.2K
R250 1.5M
S205 RESET
C217 .01μf
R252 1.2K
R246 18K 1W

"E" INPUT CHANNEL SCHEMATIC DIAGRAM



Detail No.	Berk Stock
C701	2-308
C702	2-191
C703	2-232
C704	
C705	2-581
C706	2-350
C707	2-223
C708	2-649
C709	2-217
C711	
C712	2-208
J701	17-49
L707	3-725
L708 thru L710	


FUNCTION
PERIOD B
TEST
PERIOD B X10
E/UT
TIM B-A
SCAN
E/B
E/UT X10
E/B X10
COUNT-E
E/B-A
OFF
S203
SHOWN IN OFF POSITION
1 MC OS
DWG.
7370 D
D
10 MC
B
INPUT CHANNEL
DWG.
7370 C 300
P
S
S201
SLOPE
COUNT
START
STOP
DCU
DIVIDER DRIVE
S202
SLOPE
E
INPUT CHANNEL
DWG.
7370 C 700
L
A
INPUT CHANNEL
DWG.
7370 C 300
+120v
R278
100K
PULSES TO
BE COUNTED
R202
100K
START
PULSES
R203
100K
STOP
PULSES
S203
A
S203
C
S203
D
S203
B
GATE
C201
500
C202
500
C282
500
R283
1K
R285
2.2K
CR218
IN198
R284
270Ω
L208
8.2μh
V205
6AK5
C218
500
+200v
R257
180K
V206
6AS6
+120v
R259
1K
C215
.01μf
CR214
IN198
CR215
IN198
R255
4.7K
R253
220K
R256
12K
C220
50
R287
2.2K
R286
39Ω
C256
.01μf
CR216
1T4S6HOK
R254
10K
C245
50
-60v
J203
SCOPE
GATE CONTROL
SIGNAL
R277
1.5K
L207
4.7μh
L206
10μh
+120v
R258
470Ω
795 & 705
RESET SIGNAL
XA207
785 RESET
SIGNAL
-110 v
+200 v
R238
20K
C219
.02μf
CR213
IN95
C247
.001μf
C246
.1μf
CR212
IN95
-110v
START
FLIP-FLOP
CONTROL
FLIP-FLOP
+200v
L202
25μh
L203
25μh
R272
10M
R274
3.3K
CR207
6RS1GH3TM1
R228
1M
L204
25μh
L205
25μh
R213
10K
R289
560K
CR203
IN198
CR204
IN198
R215
2.2K
R216
2.2K
R226
470K
R229
47K
R234
2.4K
R235
2.2K
R214
10K
C210
500
CR219
6RS1GH3TM1
C208
10
R219
47K
V202
6922
R223
47K
C211
10
CR217
6RS1GH3TM1
C212
10
R230
47K
V203
6922
R236
47K
C214
10
CR205
IN198
R217
12K
L209
L210
CR206
IN198
CR208
IN198
L211
L212
CR209
IN198
R218
2.2K
R227
12K
R270
12K
R221
20K
R222
2.7K
C209
.001μf
R225
20K
R281
100K
R282
270K
R232
20K
R233
2.7K
C213
.001μf
C255
.01μf
R280
68K
C257
10
-110v
R240
620K
S204
R273
1.5M
R241
68K
DISPLAY
R242
33K
R243
12M
C216
.5μf
R247
10K
CR211
C01286
R275
2.2K
RESET
CONTROL SIGNAL
R271
470K
R245
27K
R244
8.2K
R250
1.5M
S205
RESET
C217
.01μf
R252
1.2K
R246
1.8K
1W
RESET
GENERA
+200v

PARTS LIST, "E" INPUT CHANNEL

Refer to Dwg. No. 7370 C 700.

ABBREVIATIONS

AB	Allen-Bradley Co., Milwaukee, Wis.
BDB	Berkeley Division Beckman, Richmond, Calif.
VDC	Volts direct current

NOTE

Any resistor which does not appear in the list below is a fixed composition resistor of the value, wattage, and tolerance noted on the schematic diagram. All other electrical components are listed.

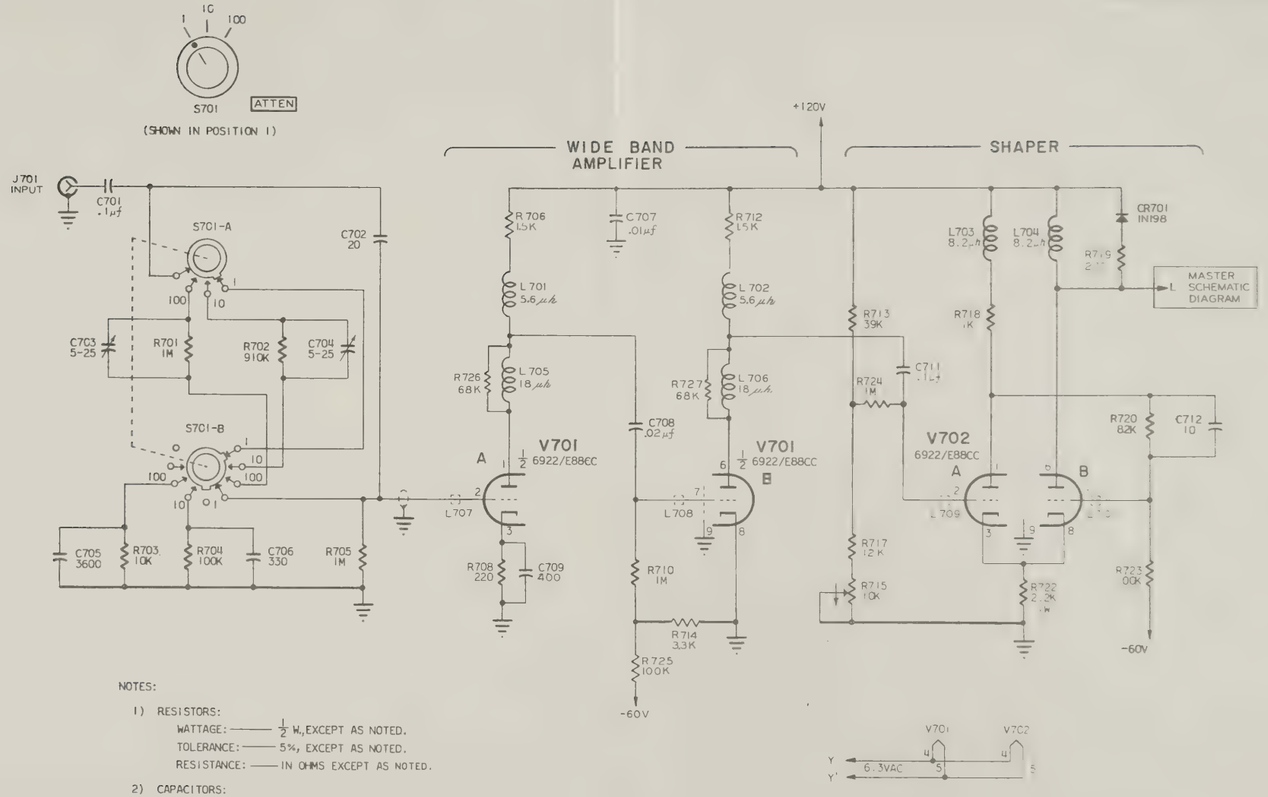
Detail No.	Berkeley Stock No.	Description	Mfr. & No.
C701	2-3086	Capacitor, paper, sub, min, 0.1μf, 400VDC	Gudeman XFS1816
C702	2-1939	Capacitor, silvered mica, 20μμf, 500VDC	Sangamo RR1420
C703	2-2326	Capacitor, ceramic trimmer, 5/25μμf	Erie 557F
C704		Same as C703	
C705	2-5819	Capacitor, silvered mica, 3600μμf, 500VDC	Sangamo CR1236
C706	2-3503	Capacitor, silvered mica, 330μμf, 500VDC	Sangamo RR1333
C707	2-2230	Capacitor, disc, ceramic, .01μf	Erie 811-.01
C708	2-6492	Capacitor, disc, .02μf	Erie 817-.02
C709	2-2172	Capacitor, silvered mica, 400μμf, 500VDC	Sangamo RR1340
C711		Same as C701	
C712	2-2082	Capacitor, silvered mica, 10μμf, 500VDC	Sangamo RR1410
CR701	8-7274	Diode, 1N198	Hughes
L701	3-4862	Choke, phenolic form, 5.6μh, fixed	Wilco 214-116
L702		Same as L701	
L703	3-4827	Choke, 8.2μh	Wilco 216-117
L704		Same as L703	
L705	3-7330	Choke, 18μh	National Coil QA-18-1
L706		Same as L705	
R715	1-3613	Potentiometer, 10K, 2W, 20%	AB JU 1032 SD3048
S701	12-7140	Switch, rotary	BDB
V701	5-4764	Tube, 6922/ECC88	Amperex
V702		Same as V701	
XV701	4-2973	Tube Socket, 9 pin, min.	Elco 377BC
XV702		Same as XV701	

ADDITIONS

J701	17-4985	Connector, coaxial	Automatic Metals UG1094/U
L707	3-7251	Ferrite bead	Ferroxcube 255 T 118 A 205
L708 thru L710		Same as L707	

June 1960

"E" INPUT CHANNEL SCHEMATIC DIAGRAM



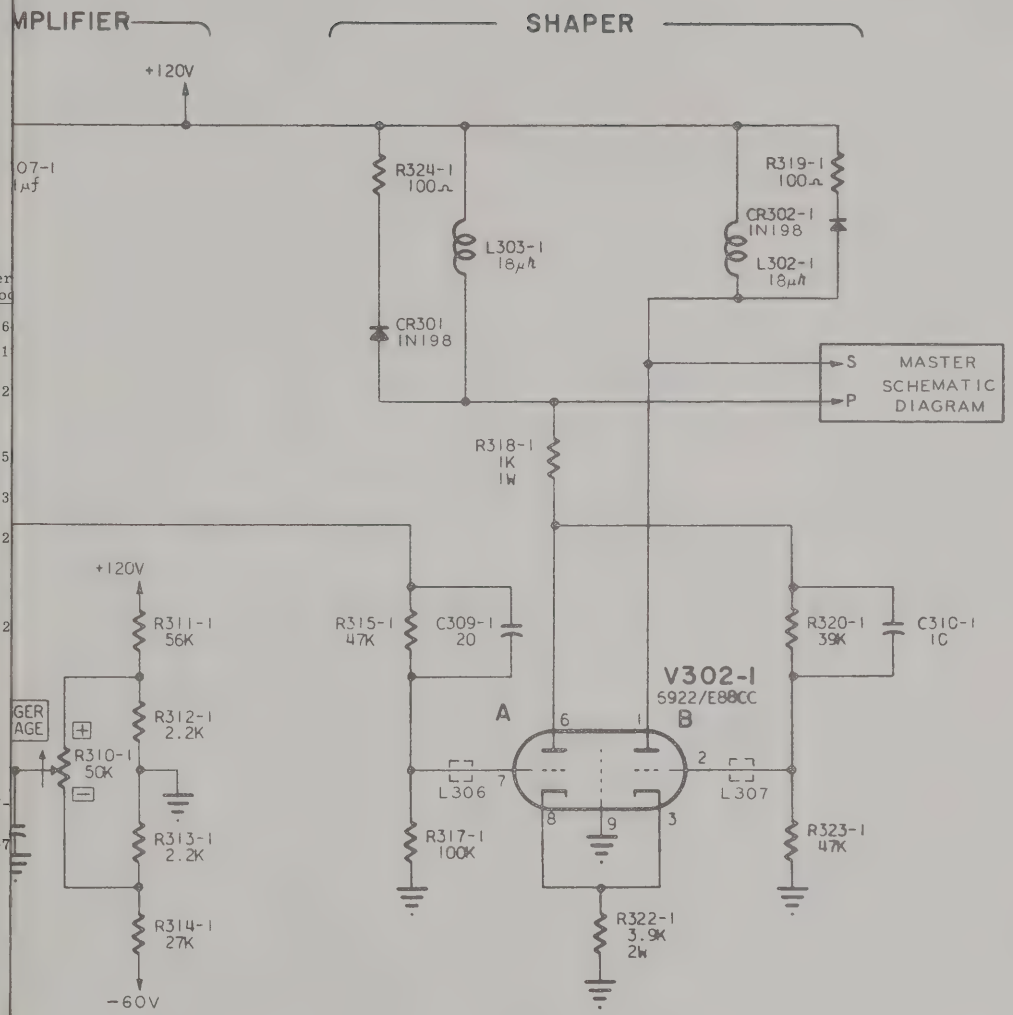
NOTES:

1) RESISTORS:
   WATTAGE: ——— 1/2 W, EXCEPT AS NOTED.
   TOLERANCE: ——— 5%, EXCEPT AS NOTED.
   RESISTANCE: ——— IN OHMS EXCEPT AS NOTED.
2) CAPACITORS:
   CAPACITY: ——— IN μμf EXCEPT AS NOTED.
3) ⊣⊢ DENOTES FERRITE SHIELDING BEAD.

June 1960

BECKMAN/BERKELEY DIVISION
DWG. NO. 7370 C 700

"A" OR "B" INPUT CHANNEL SCHEMATIC DIAGRAM



Detail No.	Ber Stoc
C301	2-6
C302	2-1
C303	2-2
C304	
C305	2-5
C306	2-3
C307	2-2
C308	
C309	
C310	2-2
J301	17-
L304	3-7
L305 thru L307	

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June 1960

BECKMAN/ BERKELEY DIVISION
DWG. NO. 7370 C 300

PARTS LIST "A" OR "B" INPUT CHANNEL

Refer to Dwg. No. 7370 C 300.

ABBREVIATIONS

AB	Allen-Bradley Co., Milwaukee, Wis.
BDB	Berkeley Division Beckman, Richmond, Calif.
VDC	Volts direct current

NOTE

Any resistor which does not appear in the list below is a fixed composition resistor of the value, wattage, and tolerance noted on the schematic diagram. All other electrical components are listed.

Detail No.	Berkeley Stock No.	Description	Mfr. & No.
C301	2-6492	Capacitor, disc, .02μf	Erie 817-.02
C302	2-1939	Capacitor, silvered mica, 20μμf, 500VDC	Sangamo RR1420
C303	2-2326	Capacitor, ceramic trimmer, 5/25μμf	Erie 557-13
C304		Same as C303	
C305	2-5819	Capacitor, silvered mica, 3600μμf, 500VDC	Sangamo CR1236
C306	2-3505	Capacitor, silvered mica, 330μμf, 500VDC	Sangamo RR1333
C307	2-2230	Capacitor, disc, ceramic, .01μf	Erie 811-.01
C308		Same as C307	
C309		Same as C302	Sangamo RR1430
C310	2-2082	Capacitor, silvered mica, 10μμf, 500VDC	Sangamo RR1410

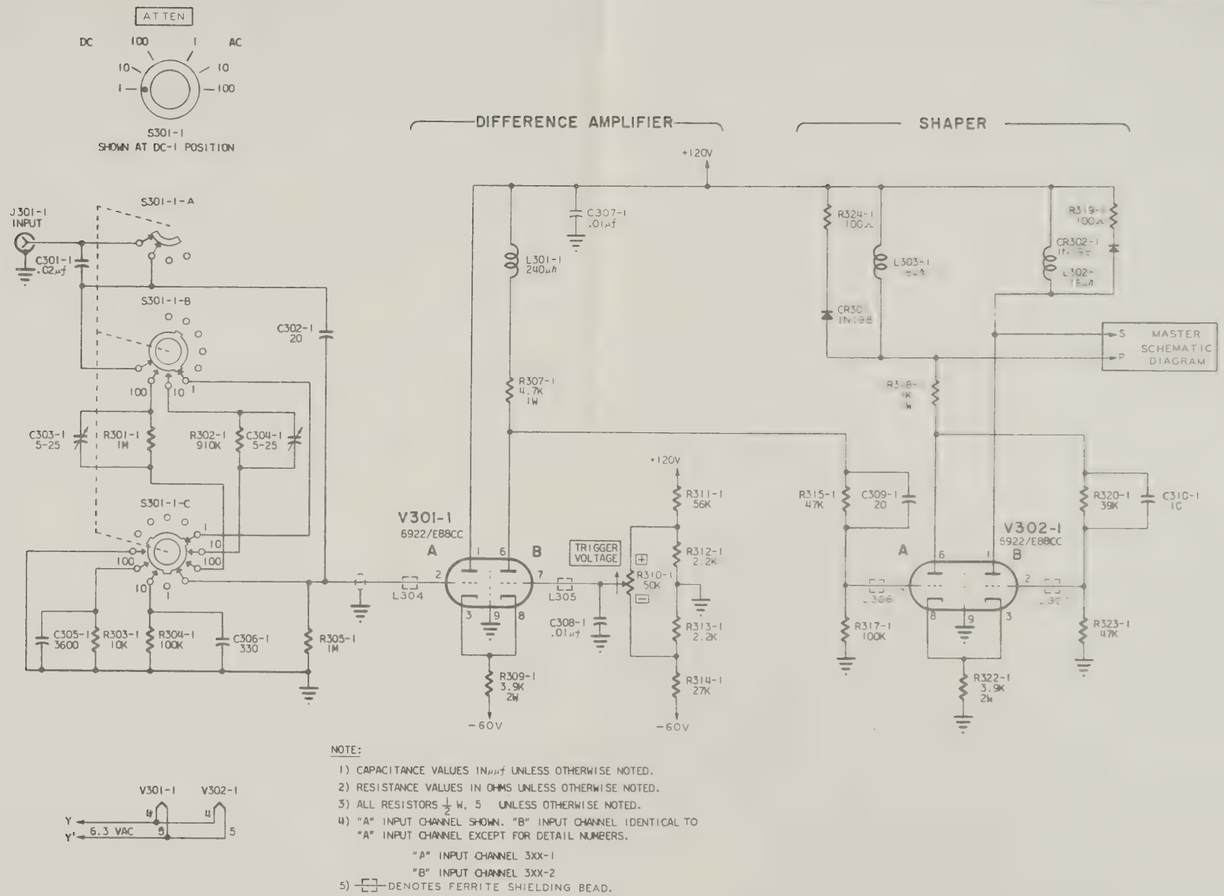
Detail No.	Berkeley Stock No.	Description	Mfr. & No.
CR301	8-7274	Diode, 1N198	Hughes
CR302		Same as CR301	
L301	3-6328	Inductor, fixed, 240μh	Wilco 3240-15
L302	3-5619	Inductor, 18μh	Wilco 1018-15
L303		Same as L302	
R310		See S301	
S301	12-7237	Switch, rotary, concentric shaft, w/50K pot	BDB
V301	5-4764	Tube, 6922/ECC88	
V302		Same as V301	
XV301	4-2973	Tube Socket, 9 pin, min.	Elco 377BC
XV302		Same as XV301	

ADDITIONS

J301	17-4985	Connector, coaxial	Automatic Metals UG1094/U
L304	3-7251	Ferrite bead	Ferroxcube 255 T 118 A 205
L305 thru L307		Same as L304	

June 1960

"A" OR "B" INPUT CHANNEL SCHEMATIC DIAGRAM



NOTE:

1) CAPACITANCE VALUES IN μμf UNLESS OTHERWISE NOTED.
2) RESISTANCE VALUES IN OHMS UNLESS OTHERWISE NOTED.
3) ALL RESISTORS ½ W, 5 UNLESS OTHERWISE NOTED.
4) "A" INPUT CHANNEL SHOWN. "B" INPUT CHANNEL IDENTICAL TO "A" INPUT CHANNEL EXCEPT FOR DETAIL NUMBERS.
   "A" INPUT CHANNEL 3XX-1
   "B" INPUT CHANNEL 3XX-2
5) ⊏⊐ DENOTES FERRITE SHIELDING BEAD.

June 1960

BECKMAN/ BERKELEY DIVISION
DWG. NO. 7370 C 300

OSCILLATOR & MULTIPLIER SCHEMATIC DIAGRAM

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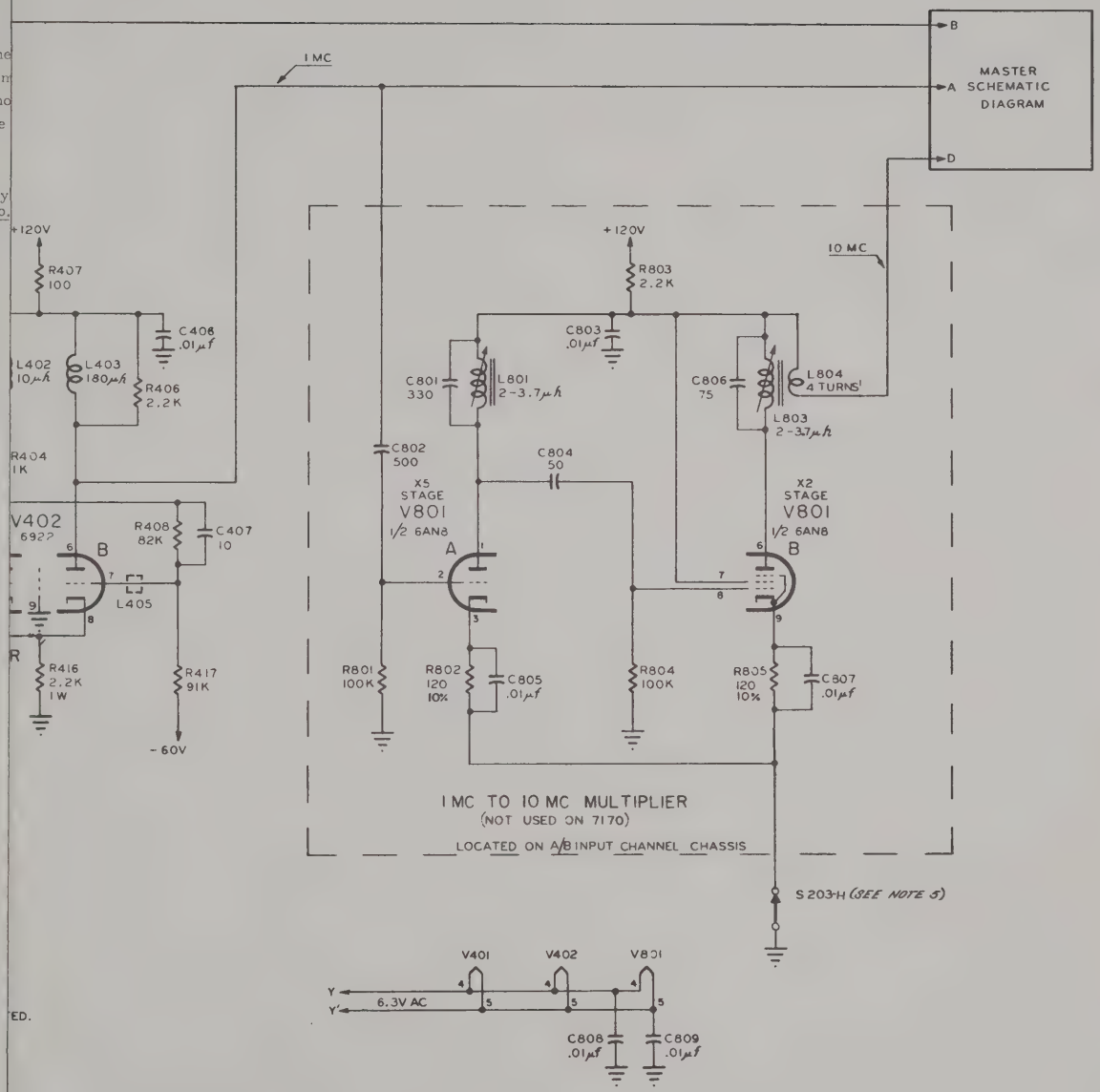
Detail No.	Berkeley Stock No.
C401	2-2230
C402	2-3068
C403	2-2172
C404	2-2763
C405 & C406	
C407	2-2082
C408	
C409	2-5491
C410	2-5706
C411	2-4268
C412	2-3242
C413	
C414	2-2136
C415 & C416	
C801	2-3505
C802	2-2137
C803	
C804	2-2141
C805	



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June 1960

BECKMAN/ BERKELEY DIVISION
DWG. NO. 7370 D 421

PARTS LIST OSCILLATOR & MULTIPLIER

Refer to Dwg. No. 7370 D 421

NOTE

The following parts list includes all electrical components except fixed composition resistors whose value, rating, and tolerance are given on the schematic diagram.

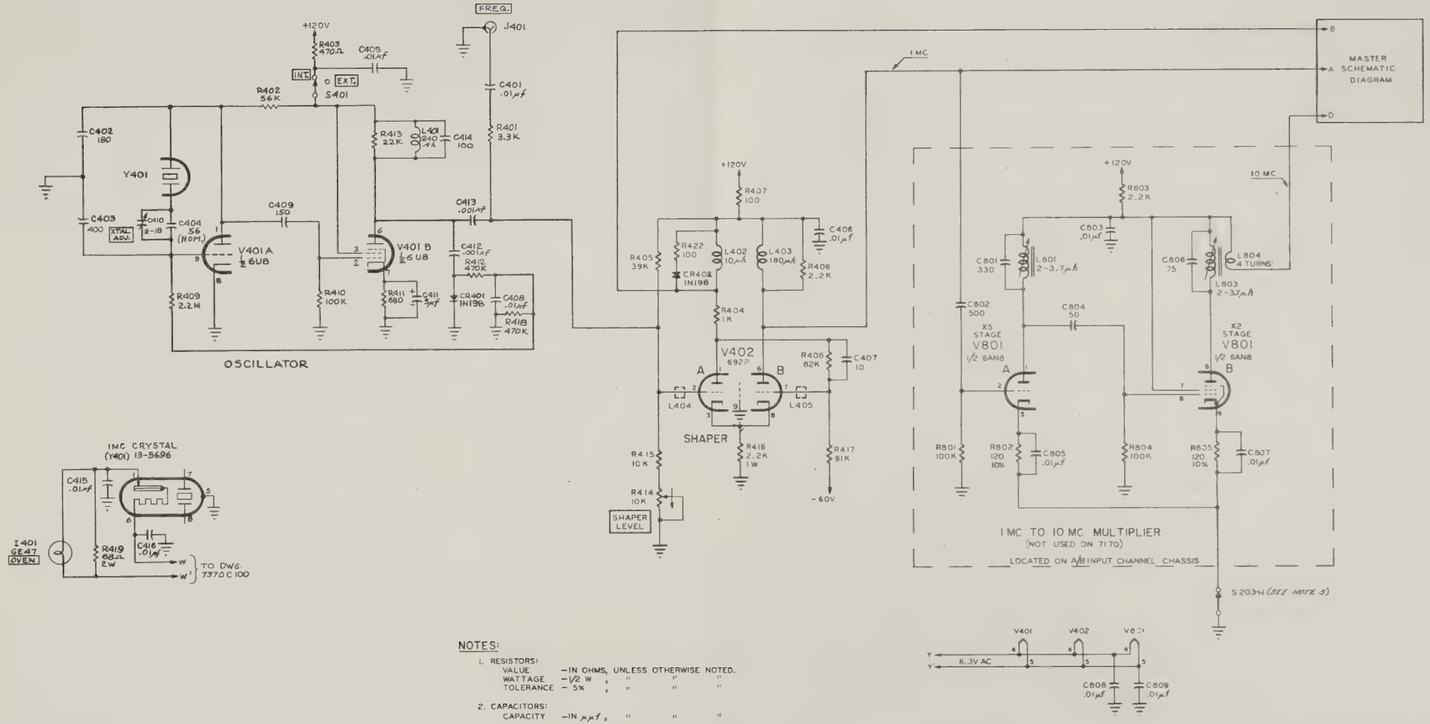
ABBREVIATIONS

AB	Allen Bradley Company, Milwaukee, Wisconsin
B/B	Beckman/Berkeley Division, Richmond, California
CH	Cutler-Hammer, Inc., Milwaukee, Wisconsin
CTC	Central Transformer Company, Chicago, Illinois
JFD	JFD Electronics, Inc., Brooklyn, New York

Detail No.	Berkeley Stock No.	Description	Manufacturer & No.
C401	2-2230	Capacitor, ceramic, .01μf, 450V	Erie 811-.01
C402	2-3068	Capacitor, mica, 180μμf, 500V, 5%	Sangamo RR1318
C403	2-2172	Capacitor, mica, 400μμf, 500V, 5%	Sangamo RR1340
C404	2-2763	Capacitor, mica, 56μμf, 500V, 5%	Sangamo RR1456
C405 & C406		Same as C401	
C407	2-2082	Capacitor, mica, 10μμf, 500V, 5%	Sangamo RR1410
C408		Same as C401	
C409	2-5491	Capacitor, mica, 150μμf, 500V, 5%	Sangamo RR1315
C410	2-5706	Capacitor, glass, 2-18μμf	JFD VC-4
C411	2-4268	Capacitor, electrolytic, 5μf, 8V, +60% -20%	Barco PS8-5
C412	2-3242	Capacitor, ceramic, .001μf, 600V, 10%	Erie GPL-1000
C413		Same as C412	
C414	2-2136	Capacitor, mica, 100μμf, 500V, 5%	Sangamo DR1310
C415 & C416		Same as C401	
C801	2-3505	Capacitor, mica, 330μμf, 500V, 5%	Sangamo RR1333
C802	2-2137	Capacitor, mica, 500μμf, 300V, 5%	Sangamo RR1350
C803		Same as C401	
C804	2-2141	Capacitor, mica, 50μμf, 500V, 5%	Sangamo RR1450
C805		Same as C803	

Detail No.	Berkeley Stock No.	Description	Manufacturer & No.
C806	2-5467	Capacitor, mica, 75μμf, 500V, 5%	Sangamo RR1475
C807 thru C809		Same as C401	
CR401	8-7274	Diode, 1N198	Hughes
CR402		Same as CR401	
I401	21-1677	Lamp	General Electric #47
J401	17-4985	Connector, coaxial	Automatic UG1094/U
L401	3-6328	Inductor, 240μh	Wilco 3240-15
L402	3-5618	Inductor, 10μh	Wilco 217-118
L403	3-6694	Inductor, 180μh	Wilco 3180-15
L404	3-7251	Ferrite bead	Ferroxcube 255 T 118 A 205
L405		Same as L404	
L801	3-5286	Inductor, 2-3.7μh	CTC-X2060-1
L803		Same as L801	
L804			B/B
R414	1-0875	Potentiometer, 10K, 2W, 20%	AB JU1032 SD3048
S401	12-1643	Switch, toggle, SPST	CH8280K15
V401	5-2526	Tube, 6U8	Sylvania
V402	5-4764	Tube, 6922	
V801	5-6072	Tube, 6AN8	
XI401	4-3324	Socket, lamp	Drake 101
XV401	4-2973	Socket, 9 pin	Elco 377BC
XV402		Same as XV401	
XV801	4-3345	Socket, 8 pin, octal	Elco 169BC
XY401	4-3213	Socket, 8 pin, octal	Cinch 16203
Y401	13-5696	Crystal, 1MC, w/oven	B/B

OSCILLATOR & MULTIPLIER SCHEMATIC DIAGRAM



NOTES:

1. RESISTORS:
   VALUE — IN OHMS, UNLESS OTHERWISE NOTED.
   WATTAGE — ½ W, " " " "
   TOLERANCE — 5%, " " " "
2. CAPACITORS:
   CAPACITY — IN μμf, " " " "
3. DESIGNATES FERRITE SHIELDING BEAD.
4. PINS 4 AND 5 (FILAMENTS) OF V801 (MULTIPLIER) ARE EACH BYPASSED TO GROUND WITH A .01μf CERAMIC DISC CAPACITOR.
5. S203-H IS CLOSED FOR "TEST" PER B, PER BX10, AND "TIM B-A" OPEN FOR ALL OTHER FUNCTIONS; NOT USED ON MODEL 7170

FREQUENCY DIVIDER SCHEMATIC DIAGRAM

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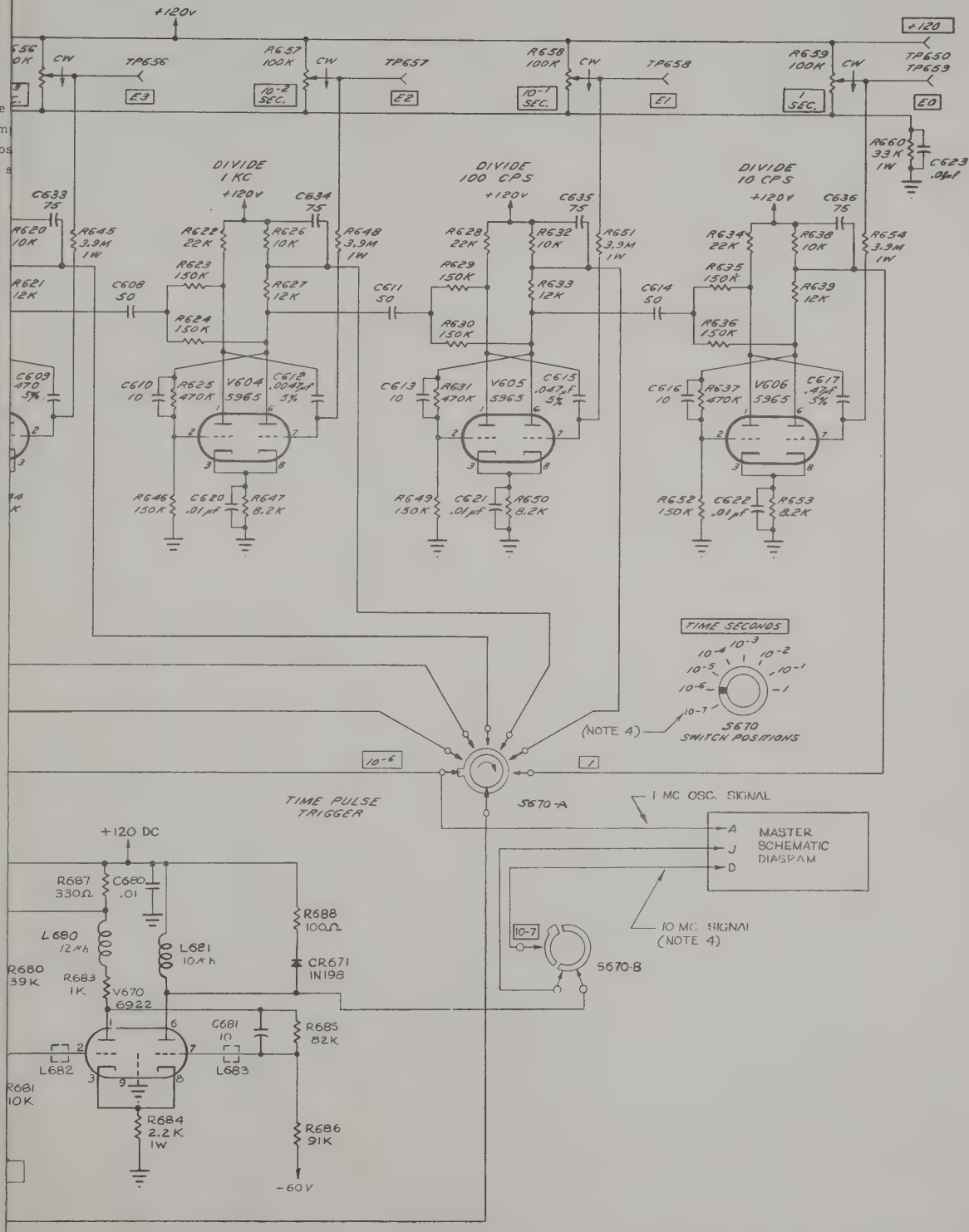
Detail No.	Berkeley Stock No.
C601	2-3242
C603	
C604	2-2082
C605	2-2141
C606	2-3879
C607	
C608	
C609	2-3574
C610	
C611	
C612	2-4206
C613	
C614	
C615	2-5603
C616	
C617	2-5604
C618	2-2230
C619 thru C623	
C625	
C626	
C627	
C628	
C630	
C632	2-5467
C633 thru C636	
C680	
C681	
CR601	8-7274



May 1960

BECKMAN/BERKELEY DIVISION
DWG. NO. 7370 D 620

PARTS LIST, FREQUENCY DIVIDER

Refer to Dwg. No. 7370 D 620

NOTE

The following parts list includes all electrical components except fixed composition resistors whose value, rating, and tolerance are given on the schematic diagram.

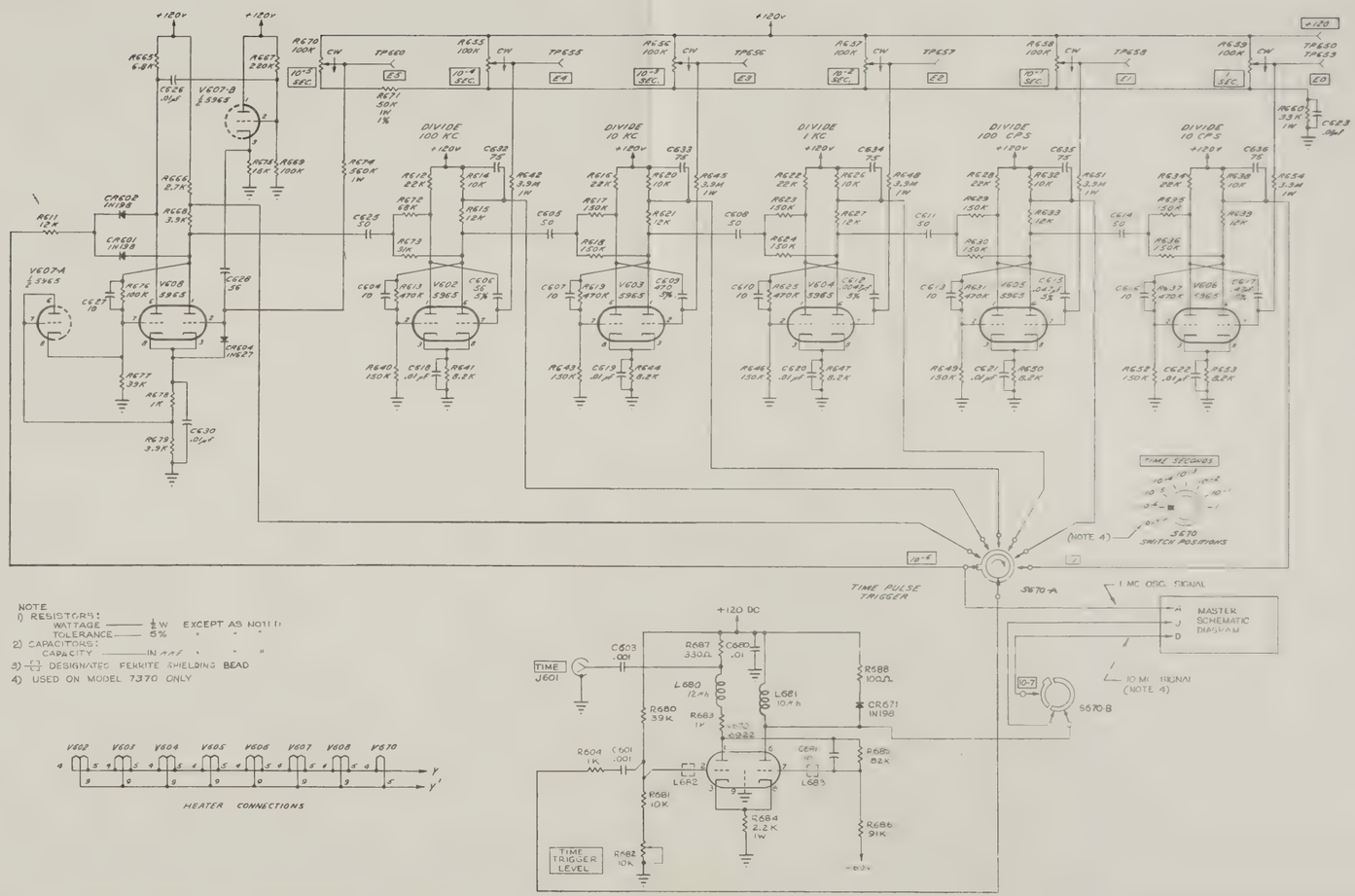
ABBREVIATIONS

AB	Allen Bradley Company, Milwaukee, Wisconsin
B/B	Beckman/Berkeley Division, Richmond, California

Detail No.	Berkeley Stock No.	Description	Manufacturer & No.
C601	1-3342	Capacitor, ceramic, .001μf, 500V, 10%	Erie GPL-1000
C603		Same as C601	
C604	2-2082	Capacitor, mica, 10μμf, 500V, 5%	Sangamo RR1410
C605	2-2041	Capacitor, mica, 50μμf, 500V, 5%	Sangamo RR1450
C606	2-3879	Capacitor, glass, 56μμf, 500V, 5%	Vitramon CY13C470JA
C607		Same as C604	
C608		Same as C605	
C609	2-3574	Capacitor, glass, 470μμf, 500V, 5%	Vitramon CY17C471JA
C610		Same as C604	
C611		Same as C605	
C612	2-4206	Capacitor, paper, .0047μf, 300V, 5%	Sprague 186P47253S3
C613		Same as C604	
C614		Same as C605	
C615	2-5603	Capacitor, paper, .047μf, 300V, 5%	Sprague 186P47353S3
C616		Same as C604	
C617	2-5604	Capacitor, paper, 0.47μf, 300V, 5%	Sprague 186P47453S3
C618	2-2230	Capacitor, ceramic, .01μf, 450V	Erie 811-.01
C619 thru C623		Same as C618	
C625		Same as C618	
C626		Same as C618	
C627		Same as C604	
C628		Same as C606	
C630		Same as C618	
C632	2-5467	Capacitor, mica, 75μμf, 500V, 5%	Sangamo RR1475
C633 thru C636		Same as C632	
C680		Same as C618	
C681		Same as C604	
CR601	8-7274	Diode, 1N198	Hughes
CR602		Same as CR601	
CR604	8-7453	Diode, 1N627	Hughes
CR671		Same as CR601	
L680	3-3567	Inductor, 12μh	B/B
L681	3-5618	Inductor, 10μh	Wilco 217-118
L682	3-7251	Ferrite bead	Ferroxcube 255 T 118 A 205
L683		Same as L682	
R642	1-6010	Resistor, 3.9M, 1W, 1%	Electra DC-1
R645		Same as R642	
R648		Same as R642	
R651		Same as R642	
R654		Same as R642	
R655	1-1340	Potentiometer, 100K, 2W, 20%	AB JU1042 SD3048
R656 thru R659		Same as R655	
R660	1-3846	Resistor, 33K, 1W, 1%	Electra DC-1
R670		Same as R655	
R671	1-4258	Resistor, 50K, 1W, 1%	Electra DC-1
R674	1-6012	Resistor, 560K, 1W, 1%	Electra DC-1
R682	1-3613	Potentiometer, 10K, 2W, 20%	AB JU1032 SD3048
S670	12-8139	Switch, rotary	B/B
TP650	17-7637	Connector, tip jack	Whitso Inc. JNP-12
TP655 thru TP660		Same as TP650	
V602	5-3301	Tube, 5965	
V603 thru V608		Same as V602	
V670	5-4764	Tube, 6922	
XV602	4-2973	Socket, 9 pin	Elco 377BC
XV603 thru XV608		Same as XV602	
XV670		Same as XV602	

June 1960

FREQUENCY DIVIDER SCHEMATIC DIAGRAM



May 1960

BECKMAN/BERKELEY DIVISION
DWG. NO. 7370 D 620

PARTS LIST, POWER SUPPLY

Refer to Dwg. No. 7370 C 100.

ABBREVIATIONS

AB	Allen-Bradley Co., Milwaukee, Wis.
BDB	Berkeley Division Beckman, Richmond, Calif.
CH	Cutler-Hammer Co., Milwaukee, Wis.
DCF	Deposited carbon film
GE	General Electric, Schenectady, N.Y.
Gen. Ind.	General Industries, Elyria, Ohio
VDC	Volts direct current
WW	Wirewound

NOTE

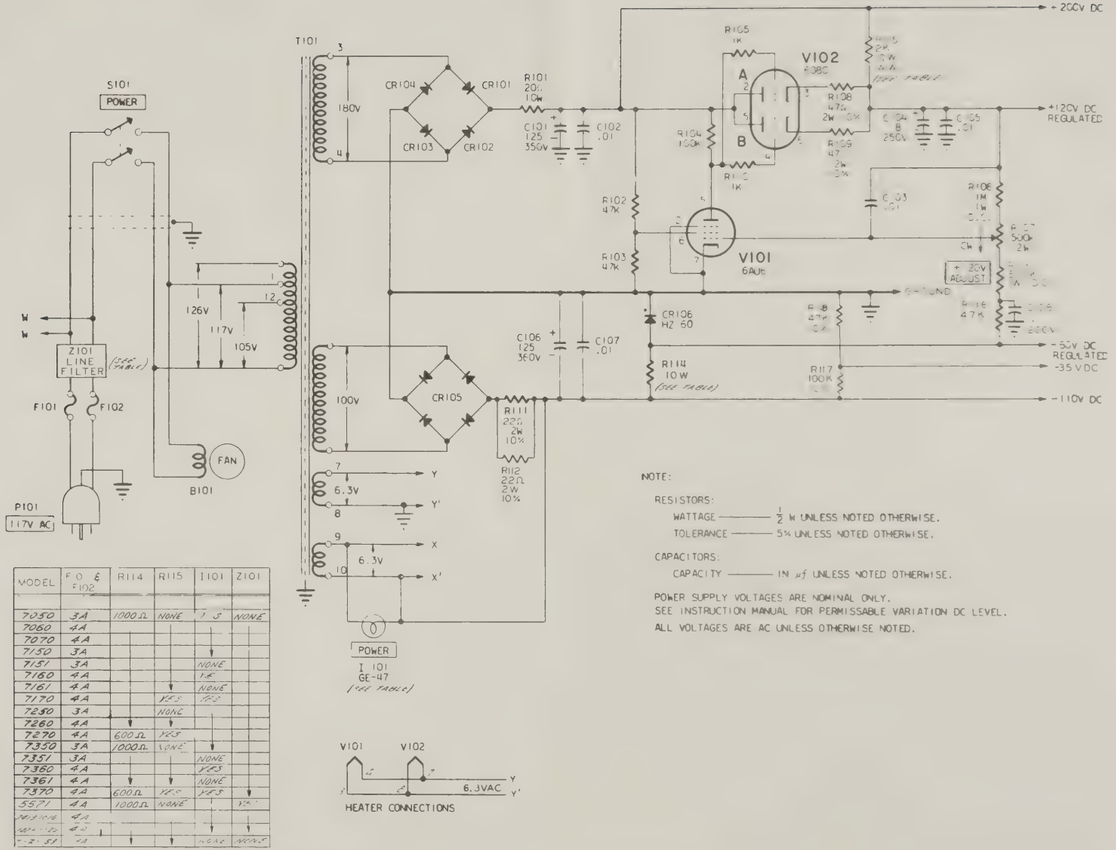
Any resistor which does not appear in the list below is a fixed composition resistor of the value, wattage and tolerance noted on the schematic diagram. All other electrical components are listed.

Detail No.	Berkeley Stock No.	Description	Manufacturer & No.
B101	9-3390	Fan Motor	Gen. Ind. A5CW
C101	2-4254	Capacitor, 125μf, 350 v.	Mallory FP140
C102	2-2230	Capacitor, disc, .01μf	Erie Type 811-, 01
C103		Same as C102	
C104	2-3982	Capacitor, electrolytic, 8μf, 250 v.	Sangamo MT 2508
C105		Same as C102	
C106		Same as C101	
C107		Same as C102	
C108	2-5937	Capacitor, 0.1μf, ±20%, 200VDC	Sangamo 330201
CR101	8-4425	Rectifier, silicon	Sarkes Tarzian M500
CR102		Same as CR101	
CR103		Same as CR101	
CR104		Same as CR101	
CR105	8-5633	Rectifier, 110 v rms, 110VDC, 130ma	GE 6R21PB3AT1
CR106	8-7228	Diode	BDB
F101	7-5824	Fuse, SloBlo, 4 amp., 125 v.	Littelfuse 313004 3 AG
F102		Same as F101	
I101	21-1677	Lamp	GE 47
R101	1-2927	Resistor, 20Ω, 10W	Tru-Ohm FRL-10
R106	1-6257	Resistor, DCF, 1 meg., 1W	Arnhold Ceramics Stemag Type A2

Detail No.	Berkeley Stock No.	Description	Manufacturer & No.
R107	1-2905	Potentiometer, Linear Carbon, 500K, 2W	AB JU 5041 SD 3048
R113	1-6258	Resistor, DCF, 500K, 1W	Arnhold Ceramics Stemag Type A2
R114 (All Models except 7270 & 7370)	1-0998	Resistor, WW, 1000Ω, 10W, 10%	Tru-Ohm FRL-10
R114 (Models 7270 & 7370)	1-7267	Resistor, WW, 600Ω, 10W	Tru-Ohm FRL-10
R115	1-1067	Resistor, WW, 2K, 10W	Tru-Ohm FRL-10
S101	12-1642	Switch, toggle, DPST	CH 8370 K8
T101	6-7265	Transformer, power	BDB
V101	5-0550	Tube, 6AU6	
V102	5-2625	Tube, 6080	
XCR101	24-4459	Spring Clip	Littelfuse 099062
XCR102		Same as XCR101	
XCR103		Same as XCR101	
XCR104		Same as XCR101	
XF101	4-3154	Fuse Post	Bussman HKP
XF102		Same as XF101	
XI101	4-1678	Lamp Socket Assy., green jewel	Dialco 81410-132
XV101	4-2972	Tube Socket, 7 pin	Elco 316BC
XV102	4-2377	Tube Socket, octal	Cinch 9950

Dec. 1959

POWER SUPPLY SCHEMATIC DIAGRAM



MODEL	F101 & F102	R114	R115	I101	Z101
7050	3A	1000Ω	NONE	1 S	NONE
7060	4A				
7070	4A				
7150	3A				
7151	3A			NONE	
7160	4A			1 E	
7161	4A			NONE	
7170	4A		YES	YES	
7250	3A		NONE		
7260	4A		YES		
7270	4A	600Ω	YES	YES	
7350	3A	1000Ω	NONE		
7351	3A			NONE	
7360	4A			YES	
7361	4A			NONE	
7370	4A	600Ω	YES	YES	
5571	4A	1000Ω	NONE		YES
5671	4A				
5671A	4A				
5871	3A			NONE	NONE

NOTE:

RESISTORS:
WATTAGE ——— ½ W UNLESS NOTED OTHERWISE.
TOLERANCE ——— 5% UNLESS NOTED OTHERWISE.

CAPACITORS:
CAPACITY ——— IN μf UNLESS NOTED OTHERWISE.

POWER SUPPLY VOLTAGES ARE NOMINAL ONLY.
SEE INSTRUCTION MANUAL FOR PERMISSABLE VARIATION DC LEVEL.
ALL VOLTAGES ARE AC UNLESS OTHERWISE NOTED.

Dec. 1959

BECKMAN/BERKELEY DIVISION
DWG. NO. 7370 C 100

Instruction Manual

MODEL 785
DECIMAL COUNTING UNIT

Lot No. _____

Beckman® Berkeley

September 12 1957

WARRANTY

Instruments sold by Berkeley Division, Beckman Instruments, Inc., (hereafter called "the Company") are warranted only as stated below.

Subject to the exceptions and upon the conditions specified below, the Company agrees to correct, either by repair, or, at its election, by replacement, any defect of material or workmanship which develops within one year after delivery of the instrument to the original purchaser by the Company or by an authorized representative, provided that investigation and factory inspection by the Company discloses that such defect developed under normal and proper use.

The exceptions and conditions mentioned above are the following:

(a) Some components and accessories by their nature are not intended to, and will not, function one year. If any such component or accessory manufactured by the Company and part of the item sold fails to give reasonable service for a reasonable period of time, the Company will, at its election, replace or repair such component or accessory. What constitutes reasonable service and what constitutes a reasonable period of time shall be determined solely by the Company after the Company is in posession of all the facts concerning operating conditions and other pertinent factors and after such component or accessory has been returned to the Company, transportation prepaid.

(b) All instruments claimed defective must be returned to the Company, transportation charges prepaid, and will be returned to the customer with the transportation charges collect, unless the item is found to be defective in which case the Company will pay all transportation charges.

(c) The Company makes no warranty concerning components or accessories not manufactured by it, such as tubes, fuses, batteries, etc. However, in the event of the failure of any component or accessory not manufactured by the Company, the Company will give reasonable assistance to the purchaser in obtaining from the respective manufacturer whatever adjustment is reasonable in the light of the manufacturer's own warranty.

(d) Except as stated above, the Company makes no warranty, express or implied (either in fact or by operation of law), statutory or otherwise; and, except to the extent stated above, the Company shall have no liability under any warranty, express or implied (either in fact or by operation of law), statutory or otherwise.

(e) The Company expressly disclaims any liability to its customers, dealers, and to users of its products, and to any other person or persons for consequential damages of any kind and from any cause whatsoever arising out of or in any way connected with the manufacture, sale, repair, replacement of, or arising out of or in any way connected with the use of any of its products.

(f) Representations and warranties made by any person, including representatives of the Company, which are inconsistent or in conflict with the terms of this warranty (including but not limited to the limitation of the liability of the Company as set forth above) shall not be binding upon the Company unless reduced to writing and approved by an officer of the Company.

(g) This warranty shall be governed by the laws of the State of California.

Claims for damage in shipment should be filed promptly with the transportation company.

All correspondence concerning the instrument should specify the model and serial number. This information appears on the company name plate. Any inquiry concerning details of operation, possible modifications, etc., should be addressed to the Sales Department, Berkeley division of Beckman Instruments, Inc., Richmond 4, California.

REPAIR SERVICE

Experienced service personnel and special test equipment are available at the factory to perform any necessary repairs. Every effort will be made to expedite the repair of instruments returned for servicing. Repair work will be performed only upon receipt of a written purchase order or authorization. Instruments to be repaired should be addressed to SERVICE AND REPAIR DEPARTMENT with transportation charges prepaid. Repaired instruments will be returned to the purchaser with transportation charges collect.

Berkeley reserves the right to make changes in design at any time without incurring any obligation to modify equipment previously purchased to conform to subsequent design changes.

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GENERAL DESCRIPTION

The Model 785 is a direct-reading, plug-in decimal counting unit. A decimal counting unit (DCU) registers voltage pulses applied at an input. Starting from zero it counts to nine, returning to zero on the tenth pulse and simultaneously generating an output signal. The count score is indicated by the illumination of one of ten neon lights placed behind a numbered acetate panel. This unit will count at a maximum rate of 1,100,000 pulses per second. This output is suitable for driving the Model 705 DCU or any modification of it (705AH, 705AK etc.) Decimal counting units may be connected in cascade (output of one to input of next), thus forming a counter whose total capacity depends only on the number of units in the chain. For example, a chain consisting of one 785 followed by five 705AH's will count to 999,999, returning to "000,000" on the 1,000,000th input pulse.

The unit also generates a binary-coded decimal readout in the form of high or low voltages at each of four pins on the DCU plug.

SPECIFICATIONS

Count Indication

Illuminated decimal digits

Input Requirements

Negative pulses. (See "OPERATION")

Resolution of Paired Pulses

0.8 μseconds

Maximum Counting Rate

1,100,000 Counts-per-second

Output Characteristics

Designed to drive a Model 705A DCU or any modification of it. (See "OPERATION".)

Reset

Reset to zero by negative pulse applied to pin 8 of plug.

Power Requirements

Heaters: 6.3V a-c at 1.8 amps near ground potential.

Plates:

Plates: 175 to 260 volts. (Design center is 210 volts at 45 ma.)

Construction

Plug-in unit which fits into standard 11-pin tube socket.

Dimensions

1-3/8" by 5-5/8" by 5-3/8"

Weight

1 pound

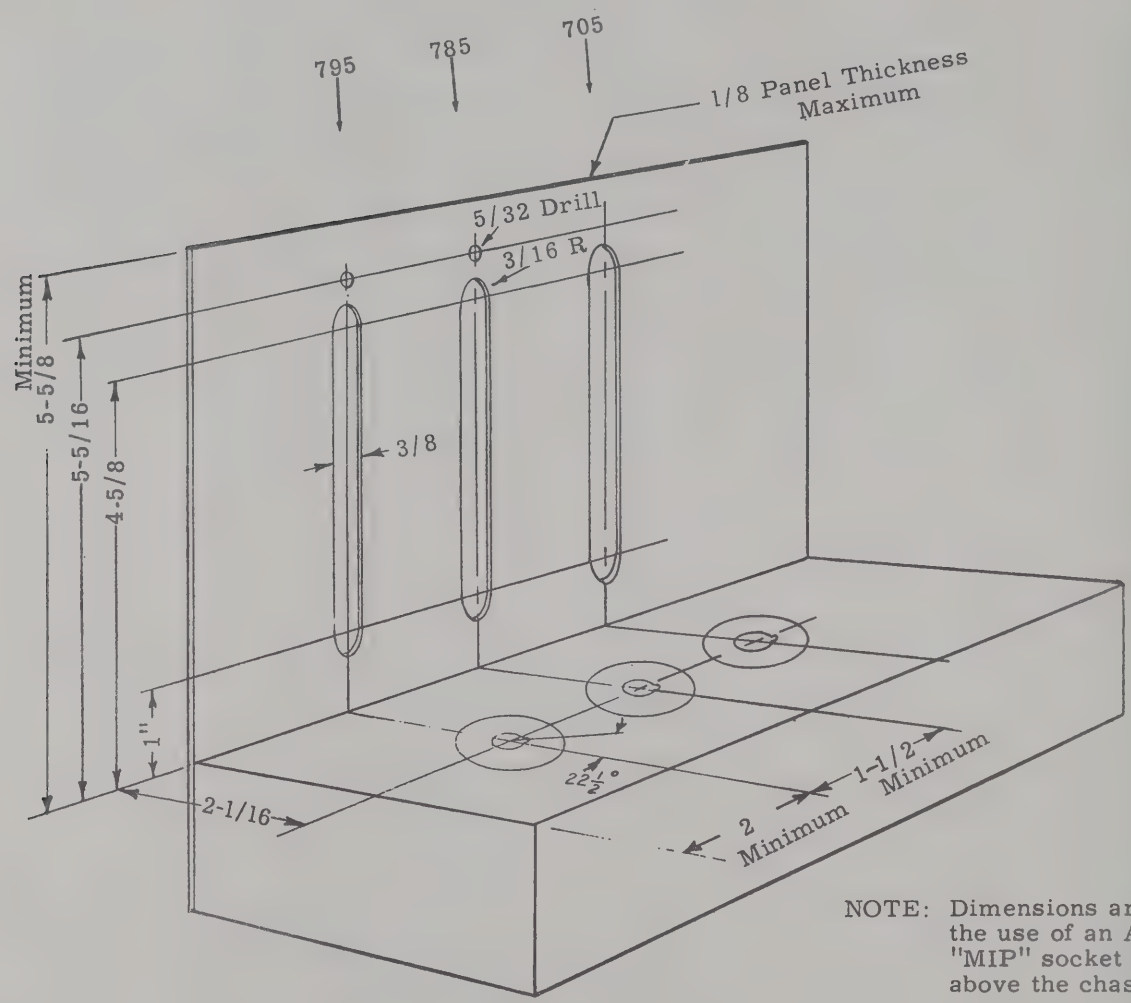
Tube Complement

Four type 12AV7.

INSTALLATION AND OPERATION

When purchased as part of another instrument, the decimal counting units are fully installed and ready to function. DCU's purchased separately should be installed and operated in accordance with the directions that follow.

Mounting. Figure 1 shows the dimensions of a chassis suitable for mounting one of these DCU's together with a Model 795 (10MC) and a Model 705 (100KC).



NOTE: Dimensions are based on the use of an Amphenol "MIP" socket mounted above the chassis.

The drawing shows the chassis dimensions for mounting Models 795, 785, and 705 DCU's side by side.. Spacing between all units (or additional units) is identical.

FIGURE 1.

MOUNTING DIMENSIONS FOR MODEL 785 OR 795 DECIMAL COUNTING UNIT

INPUT REQUIREMENTS

A negative pulse of 7 volts peak amplitude is required to trigger the unit. The rise time should be less than 0.12 microseconds, and the duration at least 0.25 microseconds. When the unit is powered by an unregulated supply, the drive amplitude should be proportional to the actual B+ voltage.

OUTPUT CHARACTERISTICS

The output is a rectangular waveform as shown in Figure 4. It is represented at the output terminal as a change in direct current voltage level. During count display "0" thru "3" it is 115 volts; during count display "4" thru "9", 205 volts. Ordinarily, the 90-volt negative transient produced at the count of ten drives the following decimal counting unit.

The load imposed on a unit must not be more than a 27,000 ohm resistor in series with a 39 $\mu\mu$f capacitor to ground.

METHOD OF RESET

Regardless of the number of units, all may be set back to zero by applying a negative pulse to a common line connected to pin 8 of the 11-pin socket.

BINARY CODE READOUT

The output at pins 2, 6, 9, and 10 of the DCU plug may be used to operate another binary coded readout or printing device. Refer to the Binary Readout Code table on page 6 to learn the relationship between binary digits and plug terminal pins.

CIRCUIT DESCRIPTION

THE BINARIES

The Model 785 DCU contains four "flip-flop" circuits referred to here as binaries. These circuits are modifications of the Eccles-Jordan trigger circuit.

Figure 2 shows a typical binary. It consists of two triode voltage amplifiers with the plate of each direct-coupled to the grid of the other. With no input this circuit assumes one of two stable states: V1 conducting steadily and V2 cut off, or V2 conducting and V1 cut off. Suppose V1 is not conducting. Then, its plate is near the B+ voltage. A portion of this voltage, applied to the grid of V2 through the voltage dividing network R4 and R8, raises this grid above cut-off and permits V2 to conduct. While V2 is conducting, the low positive potential at its plate, coupled to the grid of V1 through the dividing network R3 and R7, holds this grid several volts below cut-off. Since small changes in the potential at the grid

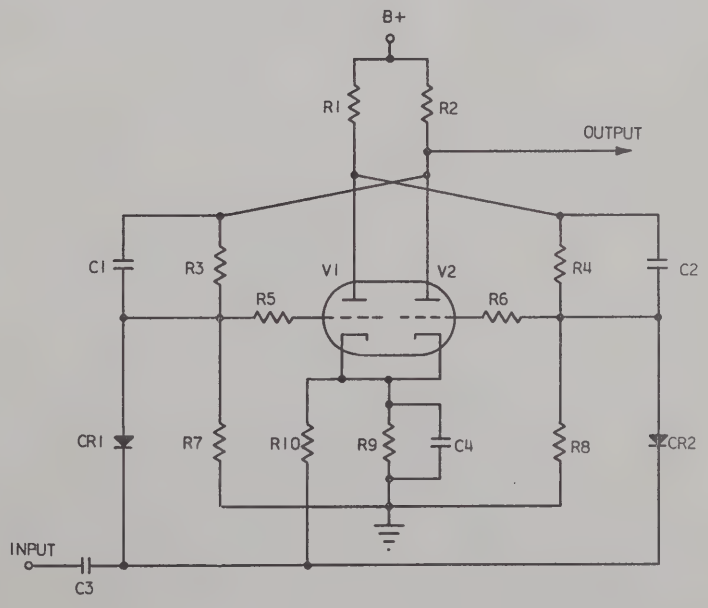


FIGURE 2.
A TYPICAL BINARY STAGE

of V1 will not raise it above cut-off, this state is stable and will persist until disturbed by an appreciable input signal. Notice that, since the circuit is symmetrical, the opposite state is equally stable.

The circuit is triggered from one state to another by negative transients applied at the input. The input diodes CR1 and CR2 form a gating system which couples the pulse formed at C3 to the grid of the conducting triode but blocks it from the grid of the other triode. Suppose, as before, that V1 is cut off and V2 is conducting. The diode side of C3 will carry a potential of about 40 volts (the same as that on the grid of V2). An applied transient will cause this potential to drop momentarily toward 30 volts. CR1 will not conduct since its plate is negative of 30 volts. However CR2 will conduct and the negative transient at the grid of V2 will lower tube current and cause an amplified rise in plate voltage. This rise will carry the grid of V1 above cut-off. The moment V1 conducts, the drop in voltage at its plate, coupled to the opposite grid, re-enforces the negative transient there. This regenerative action proceeds rapidly until V2 is cut-off and V1 is conducting at a steady rate. The next adequate input transient causes a reverse action and returns the binary to its original state. Thus, the binary completes a cycle for every two input transients applied, making it a scale of two. The output is the drop in voltage at one of the plates as that triode begins to conduct. This output, consisting of one negative transient for every two input transients, is suitable for driving another binary. By connecting binaries in cascade (output of one to input of the next), a counter having a scale of any power of two can be built. A chain of three cascaded binaries would be a scale-of-eight (2^3). If we call the input pulses driving such a chain "counts", the operation may be described as follows. The first binary will produce a negative pulse upon counts 2, 4, 6 and 8. The second binary will generate output pulses at counts 4 and 8, and the third binary will produce a pulse only at count 8. Count 8 completes a full cycle; the binaries will then be in the same state they were in before the first count.

THE SCALE OF TEN

In the Model 785 three binaries are connected in cascade to form a scale of eight. A fourth binary is arranged to block the input to the second binary during two input pulses to the counter, so that ten rather than eight pulses are required to produce a complete cycle. Figure 3 is a block diagram of the circuit.

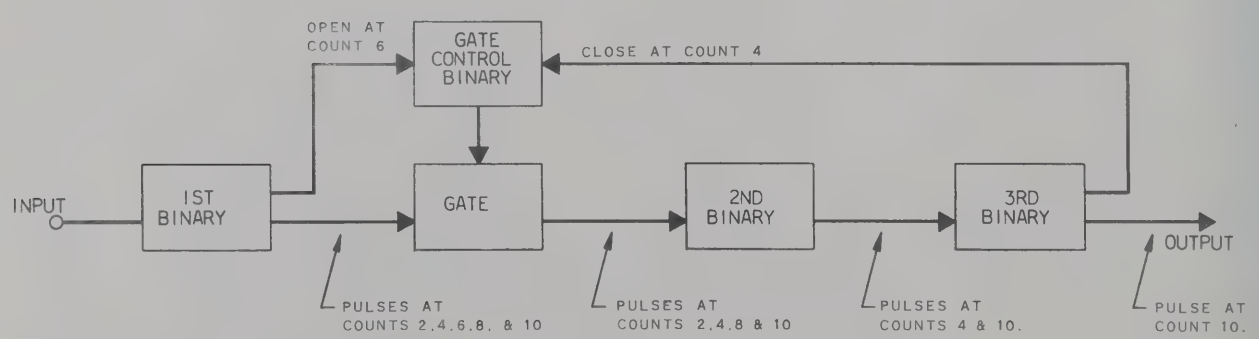


FIGURE 3.

BLOCK DIAGRAM OF MODEL 785 DCU

At the beginning of a cycle the gate control binary is in the state which holds the gate open. For the first three counts (that is, counts "1" through "3") the unit operates like a simple binary counter. At count 4 the third binary is triggered for the first time and, in turn triggers the gate control binary to its other state, closing the gate. The gate is closed during counts 5 and 6. At count 6 the first binary produces an output pulse which triggers the gate control binary back to the "open" state. During counts 7, 8, 9, and 10 the unit again operates like a simple binary chain. At count 10 the third binary produces a negative output transient which will drive another decimal counting unit.

TABLE 1

Count Display	State of Each Binary Stage			
	4th	3rd	2nd	1st
0	0	0	0	0
1	0	0	0	1
2	0	0	1	0
3	0	0	1	1
4	1	1	0	0
5	1	1	0	1
6	0	1	0	0
7	0	1	0	1
8	0	1	1	0
9	0	1	1	1
0	0	0	0	0

The operating sequence of the DCU is summarized in Table 1 which shows the state of each binary for each registered count score. The state of a binary is defined by whether or not triode B is conducting. "0" means triode B is conducting; "1" means triode B is cut off.

Figure 4 shows how voltages throughout the unit change as successive input pulses are received. Voltages are identified by circled reference points located on the schematic diagram. The output voltage used to drive succeeding binaries is taken from the junction of two plate load resistors in the right-hand triode circuit rather than from the plate itself.

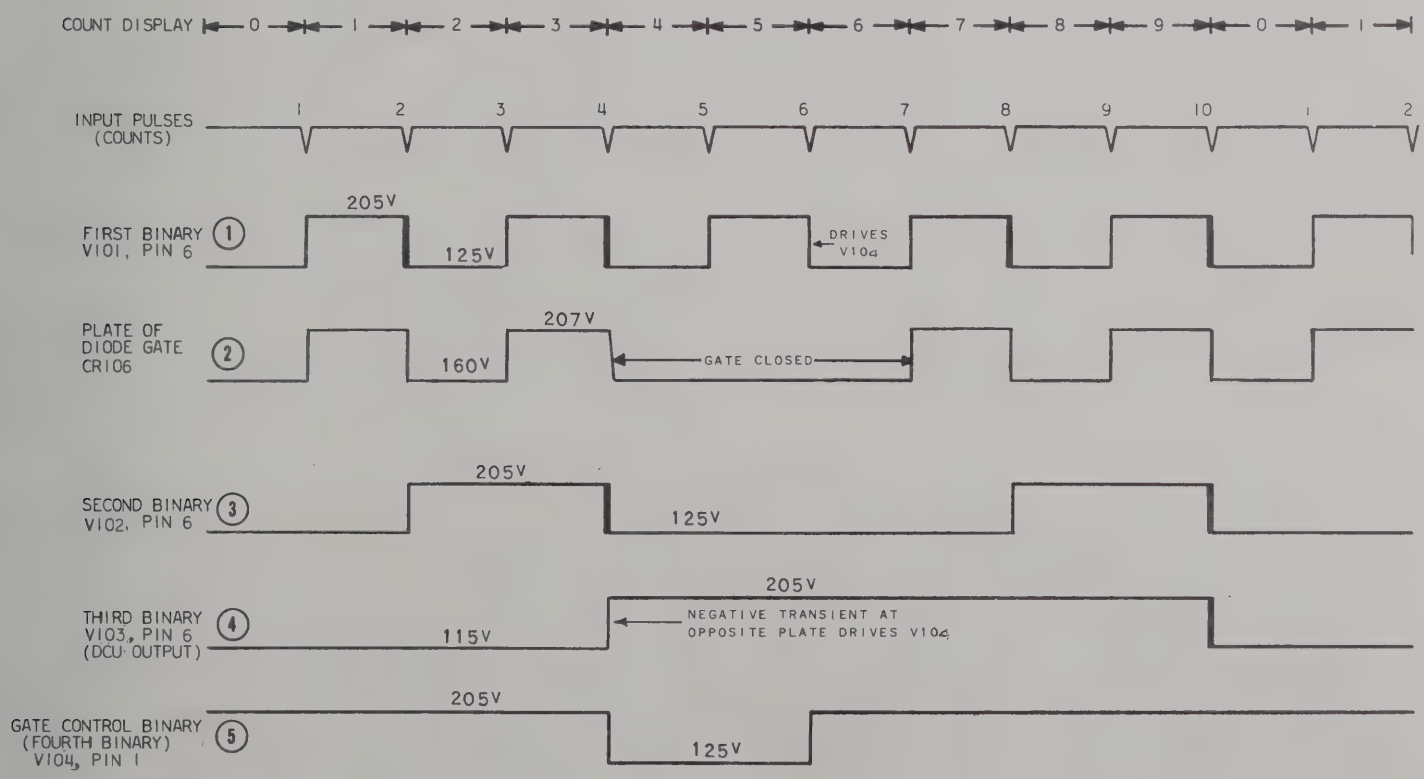

COUNT DISPLAY 0 1 2 3 4 5 6 7 8 9 0 1
INPUT PULSES (COUNTS) 1 2 3 4 5 6 7 8 9 10 1 2
FIRST BINARY ① V101, PIN 6
205V
125V
DRIVES V104
PLATE OF DIODE GATE CR106 ②
207V
160V
GATE CLOSED
SECOND BINARY ③ V102, PIN 6
205V
125V
THIRD BINARY ④ V103, PIN 6 (DCU OUTPUT)
205V
115V
NEGATIVE TRANSIENT AT OPPOSITE PLATE DRIVES V104
GATE CONTROL BINARY (FOURTH BINARY) ⑤ V104, PIN 1
205V
125V

FIGURE 4. IDEALIZED WAVEFORMS

The waveforms at this junction are identical to the plate waveforms shown in figure 4, but of smaller amplitude. The negative transients (shown in heavy lines in Figure 4) drive succeeding binaries. The negative transient from the first binary which occurs at count 6 does not reach the second binary because of the action of the gate diode CR106 described in the paragraph "Gate Control Circuit."

Actual oscilloscope waveforms are shown in figure 8. Each photograph has a number corresponding to the point on the schematic diagram figure 9 where the waveform was observed.

BINARY CODE READOUT

The output voltages of each binary are also brought out to pins 2, 6, 9 and 10 of the DCU plug to operate auxiliary binary-coded readout devices. Observe that voltage at pin 6 combines the output of the second binary and the output of the right half of the fourth binary while the voltage at pin 10 combines the output of the third binary with that of the left half of the fourth binary. The resultant modified binary code given in Table 2 below agrees with that generated by other Beckman instruments. In the table, "0" represents a voltage of -15 volts or more negative; "1" represents a voltage at ground level or more positive.

TABLE 2 - BINARY READOUT CODE

Count Display	Pin on DCU Plug			
	10	9	6	2
0	0	0	0	0
1	0	0	0	1
2	0	0	1	0
3	0	0	1	1
4	0	1	1	0
5	0	1	1	1
6	1	1	0	0
7	1	1	0	1
8	1	1	1	0
9	1	1	1	1
0	0	0	0	0

GATE CONTROL CIRCUIT

At count 4, the voltage at the right plate of the third binary (Point (4) on the schematic) rises. At the same time, the voltage at the left plate drops. The negative transient produced at the left plate is coupled to the right grid of the gate control binary (V104), causing it to switch to the state in which the left triode conducts. (Point (5)). The resultant voltage drop across R119 causes the plate of the diode gate (CR106) to drop to +160v. (Point (2)). At this time the diode plate voltage is equal to its cathode voltage, which varies between +207v and +160v. The diode does not conduct and therefore prevents the negative output transient at count 6 from reaching the second binary. However, the negative output pulse of V101 is coupled through C104 to the left grid of the control binary which now above cut-off. This switches the control binary back to its original stable state, opening the gate to pass a trigger pulse to the second binary at count 8.

OUTPUT CIRCUITRY

As the DCU cycles through counts "1" to "10", ten discreet combinations of binary states are produced, corresponding to the binary code given in the table on the preceding page. The output voltage of binaries #2 through #4 is at one of two levels which we shall designate "high" or "low". The outputs are connected to the neon bulbs in a matrix using diodes so that if one lamp terminal is connected to a low potential the voltage at that point will remain low regardless of the output level of another binary which may be connected to the same terminal. The output voltage of binary #1 is either "low" or "intermediate" because the voltage divider networks in the plate circuits prevent the voltage from reaching the "high" level.

At count "1" lamp No. 1 has both high and low potentials existing at its terminals. The circuit can be analyzed as in figure 5 for each count of the cycle in order to verify that this condition will exist for only one neon bulb at each count.

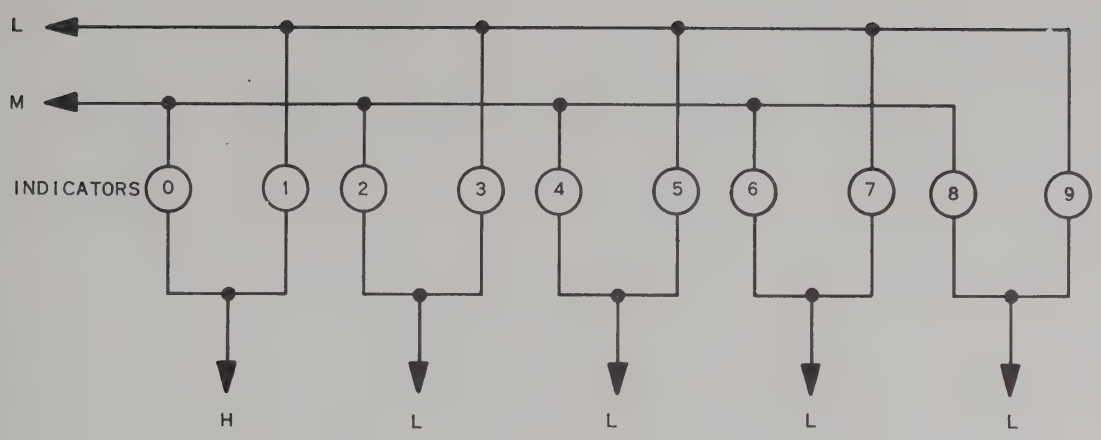


FIGURE 5.

VOLTAGE LEVELS ACROSS NEON
BULBS EXISTING AT COUNT ONE
(H= HIGH, M= INTERMEDIATE, L= LOW)

SERVICING

When a Decimal Counting Unit is suspected of counting incorrectly, it should be interchanged with a spare unit to determine whether the trouble is in the suspected unit or in the associated circuitry. This test should be made very carefully. Since the counting unit is usually the indicating device of a larger instrument, faulty operation is often ascribed to it when the symptoms of external faults are displayed.

TROUBLESHOOTING

Two methods are recommended for finding the trouble in a faulty counting unit. First, by observing the lighting sequence while driving the unit at a slow repetition rate, and second, by studying the waveform of each stage while driving the unit at a repetition rate fast enough to be conveniently viewed on an oscilloscope. It is impossible to say which method should be used in every case, since marginal failures may occur at high counting speeds and not at lower counting rates, and vice versa. The first method is the only way that a neon lamp failure can be located, and it can be used to locate component and tube failures. For this reason, it is recommended that this method be used first.

The Troubleshooting Chart (table 3) lists some common troubles which may be readily localized by observing the lighting patterns. Figure 8 shows actual oscilloscope waveforms to be used for comparison. Voltage and resistance measurements at tube pins are given in table 4.

It will be found that most failures are caused by faulty tubes.

TABLE 3

TROUBLESHOOTING CHART

NOTE: Reset unit before troubleshooting

Symptom	Cause
Unit fails to count	(a) Insufficient supply voltage
	(b) Input signal of insufficient amplitude
	(c) Input signal of wrong polarity
	(d) First stage inoperative
Unit counts spuriously	(a) Stray input signal
	(b) Pulses received through power supply
	(c) External voltages picked up by output lead
Units counts erratically	(a) Input signal too large or small, incorrect rise time
	(b) Supply voltage fluctuating too much
Unit fails to reset	(a) Stray counts from reset switch or associated circuitry
	(b) Defective component

Symptom	Cause
Unit counts in wrong sequence	
1. Skips every other number	(a) First stage defective
	(b) Input circuit supplies double pulses
2. Skips 4 and 5	(a) 4th stage not being driven by the 3rd
3. Skips 6 and 7	(a) Defective gate diode (CR106)
Repeats a pattern of numbers	
1. Two stable states per cycle (0-1 or 2-3, etc.)	(a) 2nd stage not being driven
2. Four stable states per cycle (0-1-2-3 or 6-7-8-9)	(a) 3rd stage not being driven
3. Counts up to 5, then alternates between 4-5	(a) 4th stage not being driven by the 1st
Two lamps light simultaneously	Defective diode (CR101 to CR105)

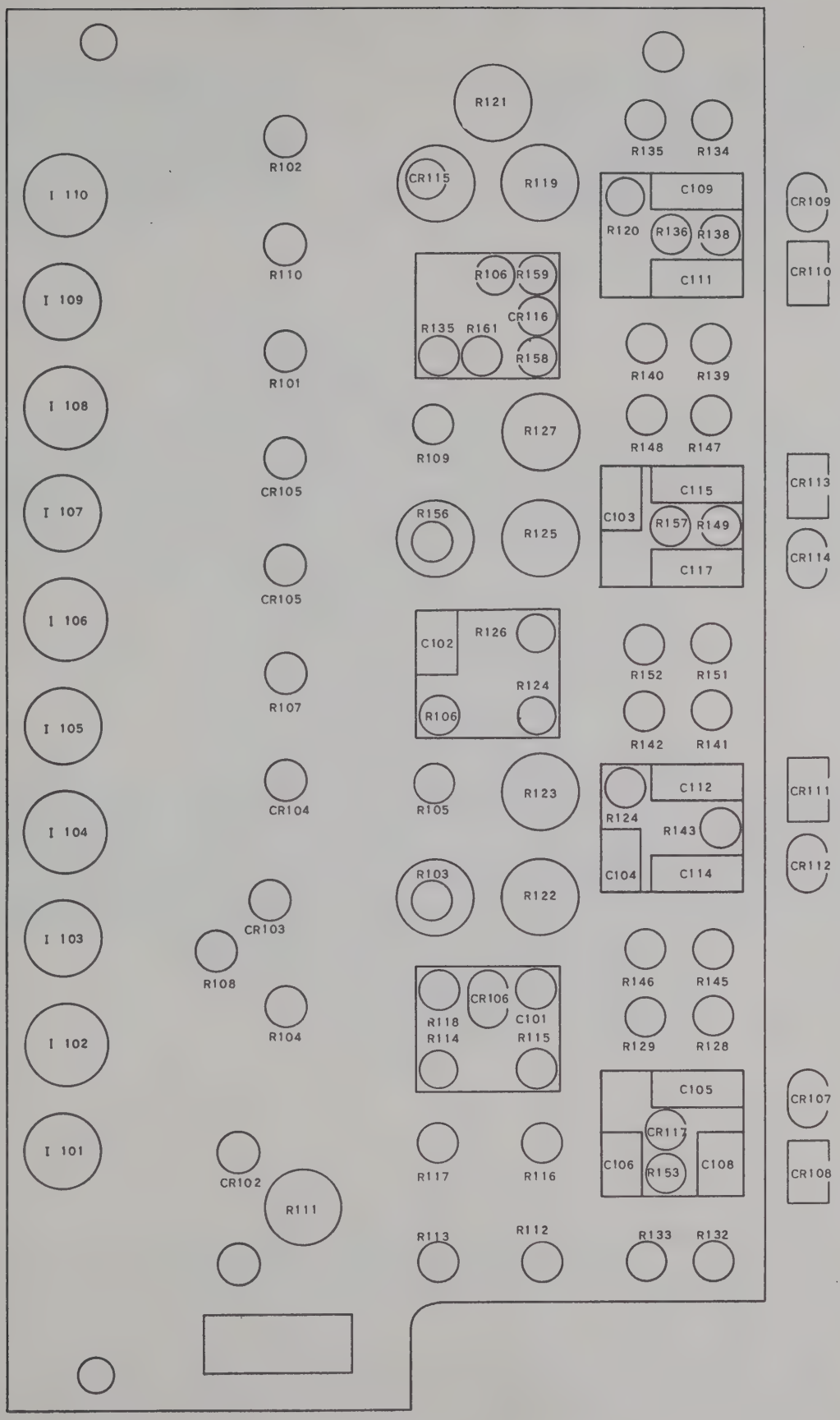
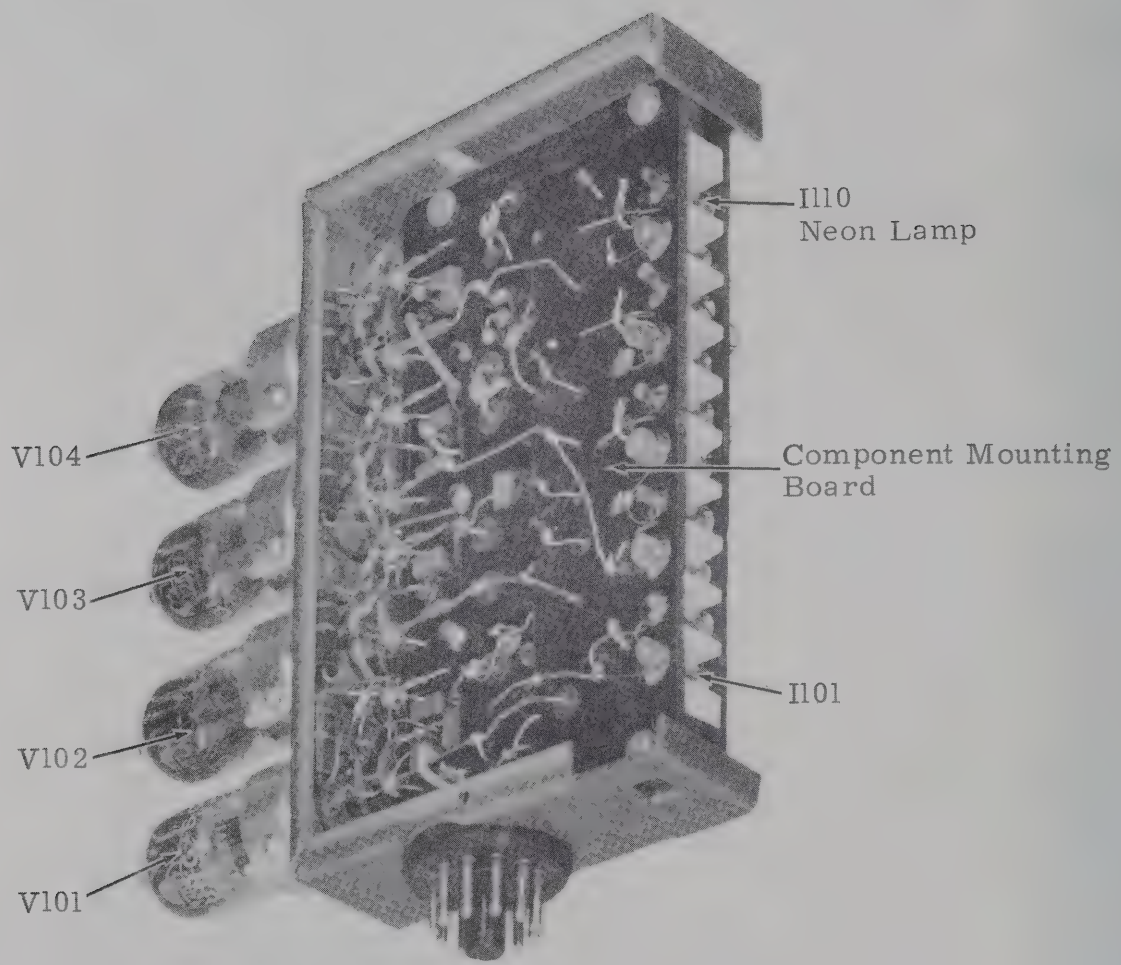


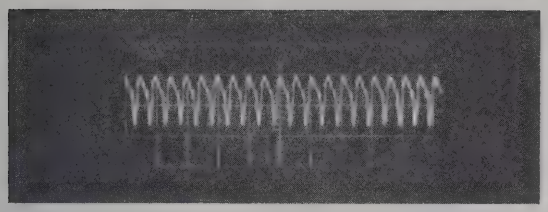
FIGURE 6.

PARTS LOCATIONS ON THE COMPONENT MOUNTING BOARD

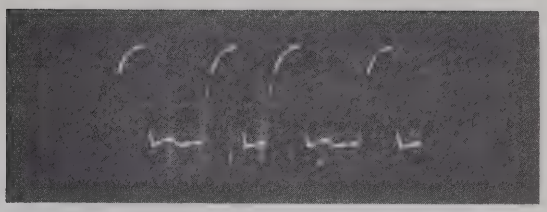


MODEL 785 DECIMAL COUNTING UNIT

(All Panels Removed)

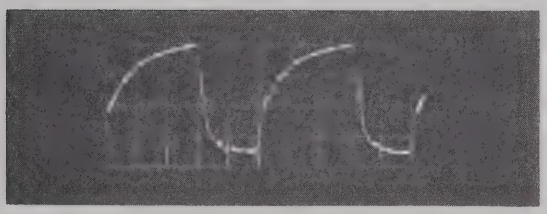


Input Pulses
8 volts peak-to-peak

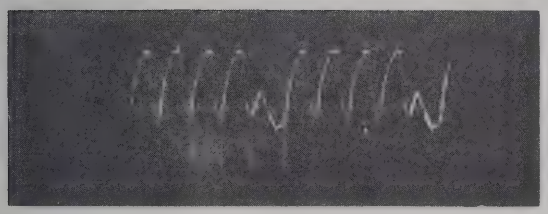


(3) Second Binary Output (V102, Pin 6)
65 volts peak-to-peak

(1) First Binary Output (V101, Pin 6)
65 volts peak-to-peak



(4) Third Binary Output (V103, Pin 6)
65 volts peak-to-peak



(2) Plate of Gate Diode (CR106)
28 volts peak-to-peak

(5) Fourth Binary (V104, Pin 1)
62 volts peak-to-peak

FIGURE 8.
TYPICAL WAVEFORMS WITH INPUT FREQUENCY OF 1 MEGACYCLE. VOLTAGE LEVELS AT HIGH FREQUENCIES MAY DIFFER CONSIDERABLY FROM THOSE SHOWN IN FIGURE 4. (TIME SCALE = 2μSECONDS/CM)

VOLTAGES

Table 4a

Note: Voltages measured to ground at count "0" with a vacuum tube voltmeter such as an RCA Volt-ohmyst Senior. B+ voltage is 200 volts.

Tube	Voltages at Tube Pin								
	1	2	3	4	5	6	7	8	9
V101	+170	+42	+56	0	0	+104	+56	+56	6.3AC
V102	+170	+38	+52	0	0	+94	+52	+52	6.3AC
V103	+170	+19	+32	0	0	+78	+33	+32	6.3AC
V104	+170	+37	+50	0	0	+92	+53	+50	6.3AC

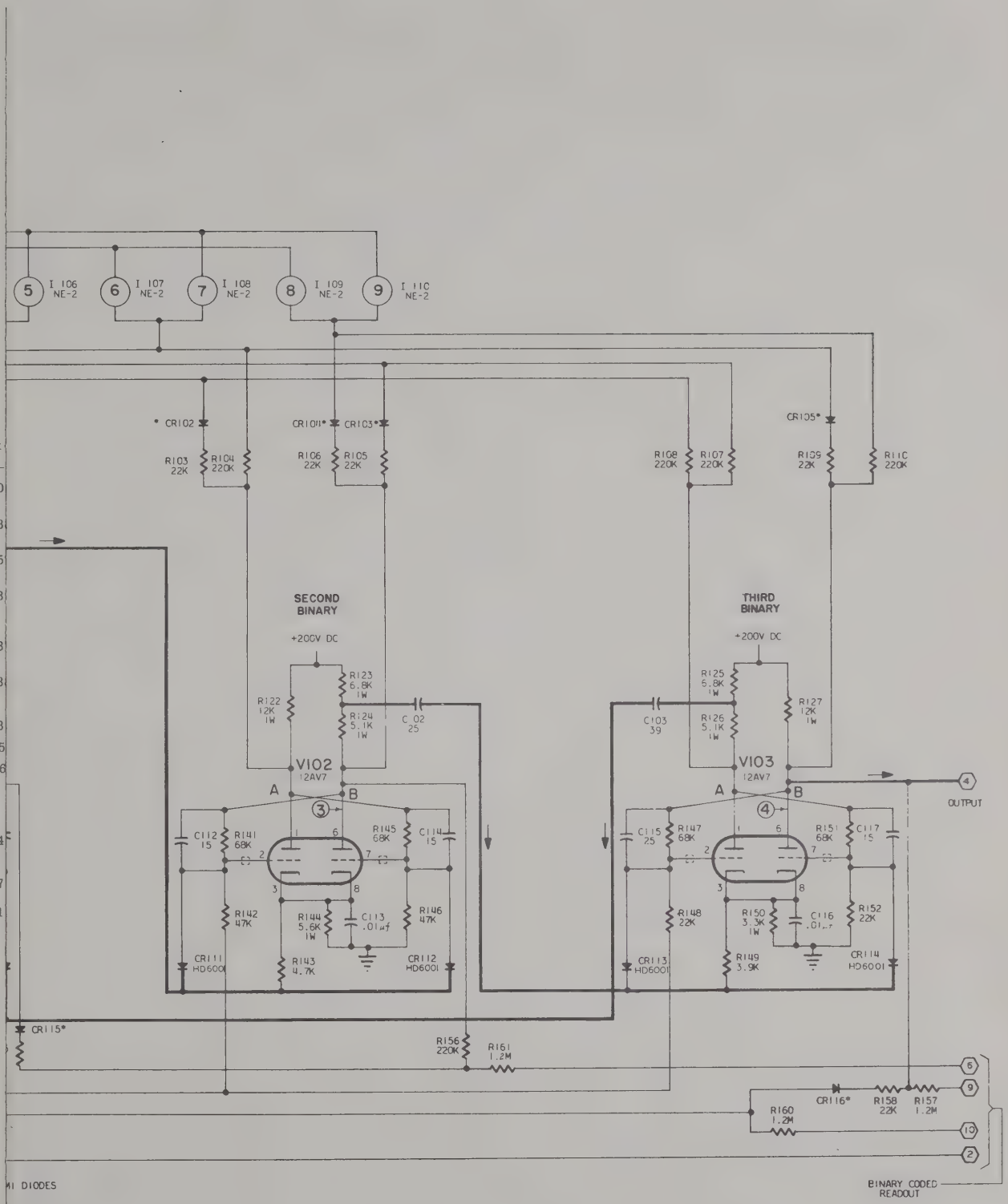
RESISTANCES

Table 4b

Note: Resistances are measured to chassis ground with the DCU removed from its socket.

Tube	Resistances at Tube Pin								
	1	2	3	4	5	6	7	8	9
V101	23K	33K	7K	∞	∞	25K	26K	7K	∞
V102	26K	18K	5.8K	∞	∞	26K	15K	5.8K	∞
V103	25K	11K	3.4K	∞	∞	24K	11K	3.4K	∞
V104	26K	21K	6K	∞	∞	26K	17K	6K	∞

Detail No.	Stock No.
C101	2-300
C102, 115, 104	2-213
C103	2-315
C105, 108, 109, C111, 112, 114, C117	2-213
C106	2-213
C107, 110, 113 C116	2-438
CR101 to CR105	8-418
CR106	8-745
CR107 to CR114	8-496
CR115 & CR116	
CR117	
I101 to I110	21-04
P101	17-17
R101, 103, 105, R106, 109, 148, R152, 155, 158	1-031



MI DIODES

ECTIONS P101

ATH

2 BEAD FERROXCUBE 255 T118 A205

August 1959

SCHEMATIC DIAGRAM
MODEL 785
DECIMAL COUNTING UNIT

VOLTAGES

Table 4a

Note: Voltages measured to ground at count "0" with a vacuum tube voltmeter such as an RCA Volt-ohmyst Senior. B+ voltage is 200 volts.

Tube	Voltages at Tube Pin								
	1	2	3	4	5	6	7	8	9
V101	+170	+42	+56	0	0	+104	+56	+56	6.3AC
V102	+170	+38	+52	0	0	+94	+52	+52	6.3AC
V103	+170	+19	+32	0	0	+78	+33	+32	6.3AC
V104	+170	+37	+50	0	0	+92	+53	+50	6.3AC

RESISTANCES

Table 4b

Note: Resistances are measured to chassis ground with the DCU removed from its socket.

Tube	Resistances at Tube Pin								
	1	2	3	4	5	6	7	8	9
V101	23K	33K	7K	∞	∞	25K	26K	7K	∞
V102	26K	18K	5.8K	∞	∞	26K	15K	5.8K	∞
V103	25K	11K	3.4K	∞	∞	24K	11K	3.4K	∞
V104	26K	21K	6K	∞	∞	26K	17K	6K	∞

PARTS LIST

Model 785 Decimal Counting Unit

(Refer to Dwg. No. 785D1)

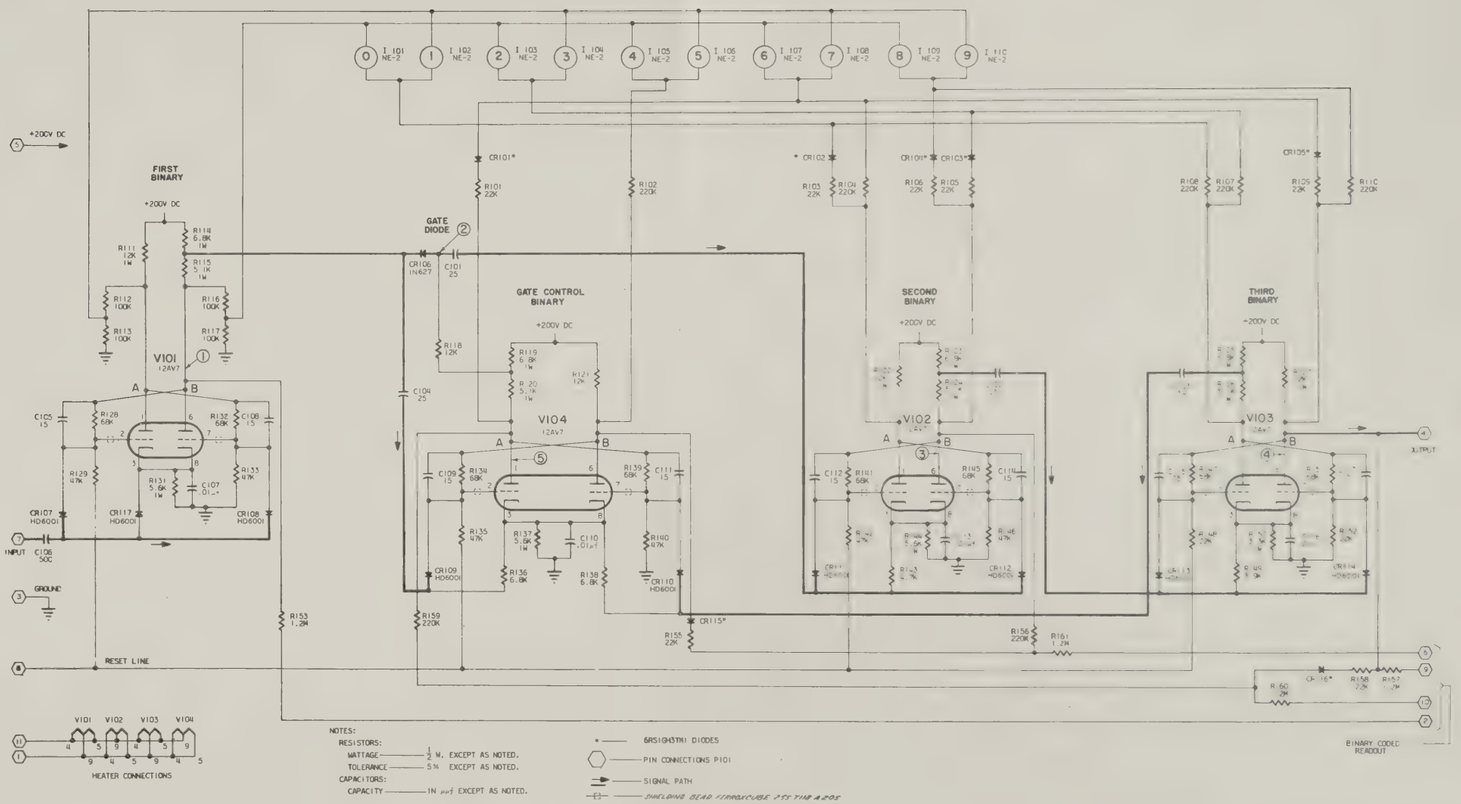
ABBREVIATIONS

AB	Allen-Bradley Company, Milwaukee, Wisconsin
Cap.	Capacitor
GE	General Electric Company, Schenectady, New York

NOTE: All resistors are 1/2 watt, 5 per cent tolerance, fixed composition unless specified otherwise.

Detail No.	Stock No.	Description	Manufacturer & No.
C101	2-3009	Cap., 25 μμfd, Tubular Ceramic	Erie GP1K
C102, 115, 104	2-2138	Cap., 25 μμfd, Silvered Mica	Sangamo DR 1425
C103	2-3157	Cap., 39 μμfd, Silvered Mica	Sangamo DR 1433
C105, 108, 109, C111, 112, 114, C117	2-2135	Cap., 15 μμfd, Silvered Mica	Sangamo DR 1415
C106	2-2137	Cap., 500 μμfd, Silvered Mica	Sangamo RR 1350
C107, 110, 113 C116	2-4388	Cap., .01 μfd, Disc, Axial Leads	Sprague S52564
CR101 to CR105	8-4182	Diode	GE 6RS1GH3TM1
CR106	8-7453	Diode, 1N627	Texas Instruments
CR107 to CR114	8-4967	Diode, HD6001	Hughes
CR115 & CR116		Same as CR101	
CR117		Same as CR107	
I101 to I110	21-0426	Lamp, 1/25 W, Wire Leads, Neon NE2	
P101	17-1719	Receptacle, 11 Pin Plug	Amphenol 86CR11
R101, 103, 105, R106, 109, 148, R152, 155, 158	1-0312	Resistor, 22 K	AB EB 2235
R102, 104, 107, R108, 110, 156, R159	1-0220	Resistor, 220 K	AB EB 2245
R111, 121, 122, R127	1-5420	Resistor, 12 K, 1 W	AB GB 1235
R112, 113, 116, R117	1-3953	Resistor, 100 K	AB EB 1045
R114, 119, 123, R125	1-5079	Resistor, 6.8 K, 1 W	AB GB 6825
R115, 120, 124, R126	1-5154	Resistor, 5.1 K, 1 W	AB EB 5125
R118	1-0157	Resistor, 12K	AB EB 1235
R128, 132, 134, R139, 141, 145, R147, 151	1-5403	Resistor, 68 K	AB EB 6835
R129, 133, 135, R140, 142, 146	1-0214	Resistor, 47 K	AB EB 4735
R131, 137, 144	1-5430	Resistor, 5.6 K, 1 W	AB EB 5625
R136 & R138	1-2396	Resistor, 6.8 K	AB EB 6825
R143	1-5433	Resistor, 4.7 K	AB EB 3325
R149	1-3609	Resistor, 3.9 K	AB EB 3925
R150	1-0736	Resistor, 3.3 K, 1 W	AB EB 3325
R153, 157, 160 R161	1-2693	Resistor, 1.2 M	AB EB 1255
R162 to R169	1-6483	Resistor, 100 Ω, 1/10 W, 10 per cent	AB TR Type
V101 to V104	5-5977	Tube, type 12AV7	
XV101 to XV104	4-6508	Tube Socket, 9 Pin Miniature w/shield	Elco 2074

August 1959



August 1959

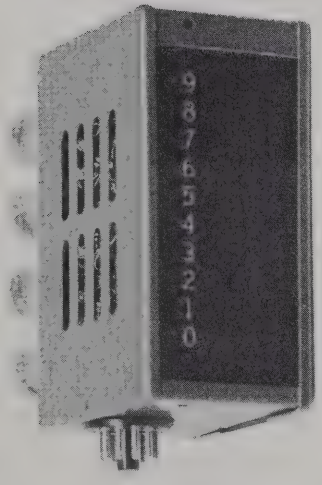
SCHEMATIC DIAGRAM
MODEL 785
DECIMAL COUNTING UNIT

VOLTAGES

Instruction Manual

MODEL 795
DECIMAL COUNTING UNIT

Lot No. _____



Beckman

Berkeley Division
2200 Wright Avenue, Richmond 3, California
a division of Beckman Instruments, Inc.

June 1958

WARRANTY

Instruments sold by Berkeley Division, Beckman Instruments, Inc., (hereafter called "the Company") are warranted only as stated below.

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(b) All instruments claimed defective must be returned to the Company, transportation charges prepaid, and will be returned to the customer with the transportation charges collect, unless the item is found to be defective in which case the Company will pay all transportation charges.

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(g) This warranty shall be governed by the laws of the State of California.

Claims for damage in shipment should be filed promptly with the transportation company.

All correspondence concerning the instrument should specify the model and serial number. This information appears on the company name plate. Any inquiry concerning details of operation, possible modifications, etc., should be addressed to the Sales Department, Berkeley division of Beckman Instruments, Inc., Richmond 4, California.

REPAIR SERVICE

Experienced service personnel and special test equipment are available at the factory to perform any necessary repairs. Every effort will be made to expedite the repair of instruments returned for servicing. Repair work will be performed only upon receipt of a written purchase order or authorization. Instruments to be repaired should be addressed to SERVICE AND REPAIR DEPARTMENT with transportation charges prepaid. Repaired instruments will be returned to the purchaser with transportation charges collect.

Berkeley reserves the right to make changes in design at any time without incurring any obligation to modify equipment previously purchased to conform to subsequent design changes.

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GENERAL DESCRIPTION

The Model 795 is a direct-reading, plug-in decimal counting unit. A decimal counting unit (DCU) registers voltage pulses applied at an input. Starting from zero it counts to nine, returning to zero on the tenth pulse and simultaneously generating an output signal. The count score is indicated by the illumination of one of ten neon lights placed behind a numbered acetate panel. This unit will count at a maximum rate of 11,000,000 pulses per second. The output is suitable for driving the Model 785 DCU, which will in turn drive a Model 705A or any modification of it (705AH, 705AK etc.) Decimal counting units may be connected in cascade (output of one to input of next), thus forming a counter whose total capacity depends only on the number of units in the chain. For example, a chain consisting of a 795 followed by one 785 and five 705AH's will count to 9,999,999 returning to "0,000,000" on the 10,000,000th input pulse.

The unit also generates a binary-coded decimal readout in the form of high or low voltages at each of four pins on the DCU plug.

SPECIFICATIONS

Count Indication

Illuminated decimal digits

Input Requirements

Negative pulses. (See "OPERATION")

Resolution of Paired Pulses

0.09 μseconds

Maximum Counting Rate

11,000,000 Counts-per-second

Output Characteristics

Designed to drive a Model 785 DCU (See "OPERATION".)

Reset

Reset to zero by negative pulse applied to pin 8 of plug.

Power Requirements

Heater Supply: 6.3V a-c at 2.2 amps near ground potential.

B- Supply: -110 volts at 80ma applied at pin 3.
B+ Supply: +120 volts at 15ma applied at pin 7.
(The B+ supply voltage is superimposed on the input signal.)

Construction

Plug-in unit which fits into standard 11-pin tube socket.

Dimensions

2-1/2" by 5-5/8" by 5-3/8"

Weight

1.5 lbs.

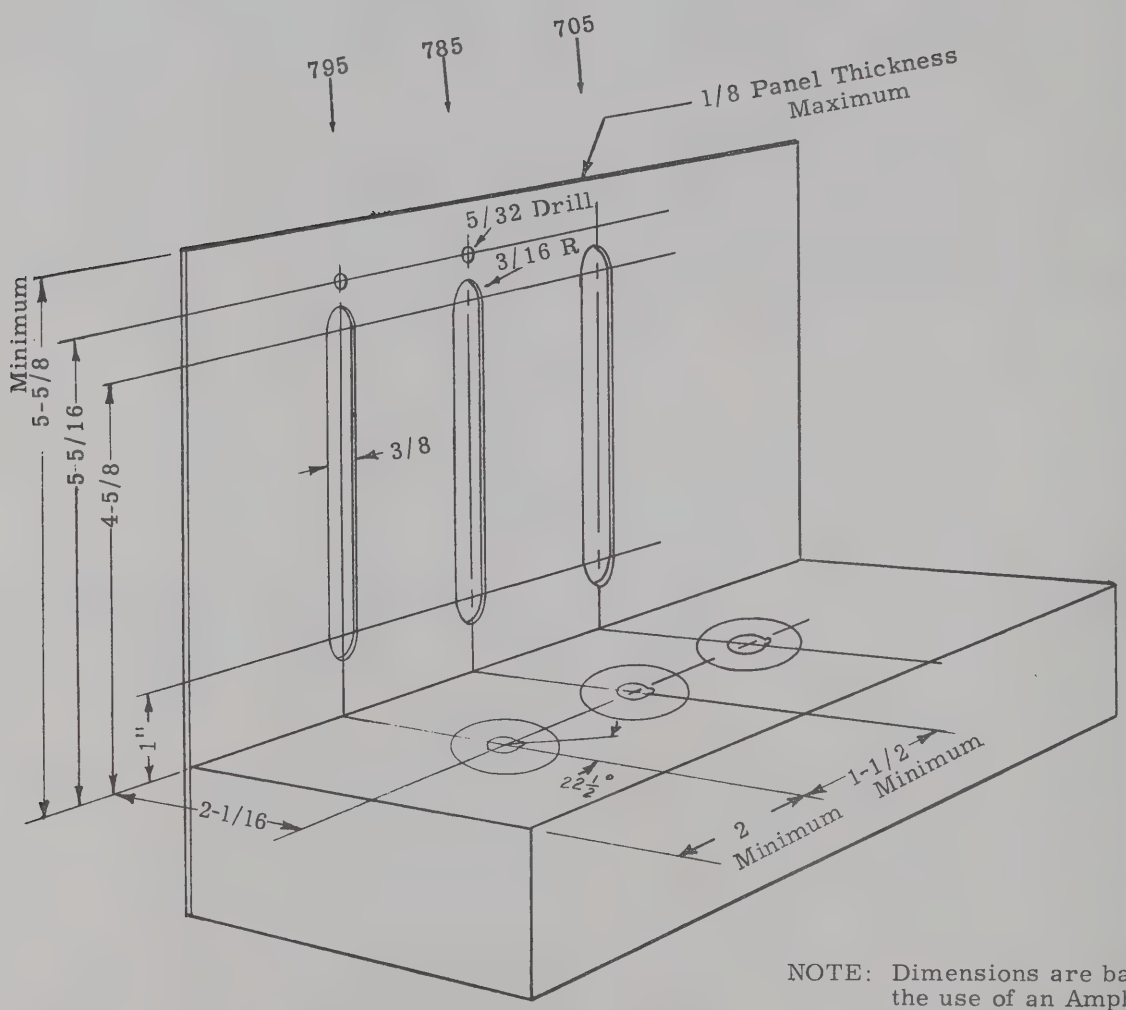
Tube Complement

4 type 6922
2 type 5964

INSTALLATION & OPERATION

When purchased as part of another instrument, the decimal counting units are fully installed and ready to function. DCU's purchased separately should be installed and operated in accordance with the directions that follow.

Mounting. Figure 1 shows the dimensions of a chassis suitable for mounting one of these DCU's together with a Model 785 (1Mc) and a Model 705A (100Kc).



NOTE: Dimensions are based on the use of an Amphenol "MIP" socket mounted above the chassis.

The drawing shows the chassis dimensions for mounting Models 795, 785, and 705 DCU's side by side. Spacing between all units (or additional units) is identical.

FIGURE 1.

MOUNTING DIMENSIONS FOR MODEL 785 OR 795 DECIMAL COUNTING UNIT

INPUT REQUIREMENTS

A negative pulse of 6 volts peak amplitude is required to trigger the unit. The rise time should be less than 0.025 microseconds, and the duration not more than 0.05 μseconds.

OUTPUT CHARACTERISTICS

The output is a negative pulse as shown in figure 7 (waveform taken at pin 4 of P101). The pulse is 7v in amplitude and 0.25 microseconds wide. This pulse is of proper amplitude to drive a Model 785 DCU.

METHOD OF RESETTING TO ZERO

Regardless of the number of units, all may be set back to zero by applying a negative pulse to a common line connected to pin 8 of the 11-pin socket.

BINARY-CODED READOUT

The output at pins 2, 6, 9 and 10 of the DCU plug may be used to operate another binary-coded readout or printing device. Refer to the Binary Readout Code on page 5 to learn the relationship between binary digits and the plug terminal pins.

CIRCUIT DESCRIPTION

THE BINARIES

The Model 795 DCU contains four "flip-flop" circuits referred to here as binaries. These circuits are modifications of the Eccles-Jordan trigger circuit.

Figure 2 shows a typical binary. It consists of two triode voltage amplifiers with the plate of each direct-coupled to the grid of the other. With no input this circuit assumes one of two stable states: V1 conducting steadily and V2 cut off, or V2 conducting and V1 cut off. Suppose V1 is not conducting. Then, its plate is near the B+ voltage. A portion of this voltage, applied to the grid of V2 through the voltage dividing network R4 and R8, raises this grid above cut-off and permits V2 to conduct. While V2 is conducting, the low positive potential at its plate, coupled to the grid of V1 through the dividing network R3 and R7, holds this grid several volts below cut-off. Since small changes in the potential at the grid of V1 will not raise it above cut-off, this state is stable and will persist until disturbed by an appreciable input signal. Notice that, since the circuit is symmetrical, the opposite state is equally stable.

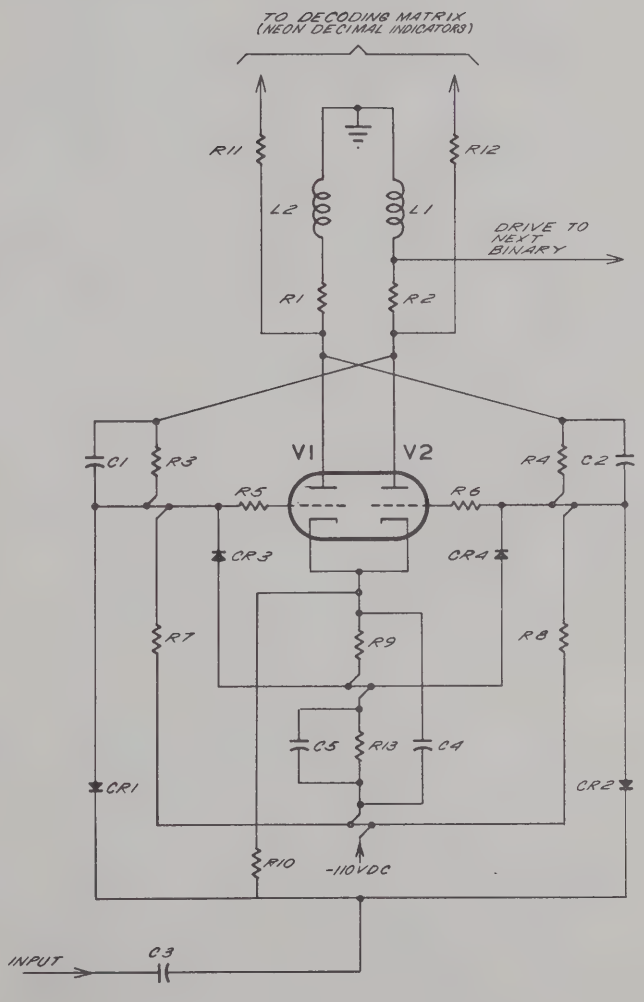


FIGURE 2.

A TYPICAL BINARY STAGE

The circuit is triggered from one state to another by negative pulses applied at the input. The input diodes CR1 and CR2 form a gating system which couples the pulse formed at C3 to the grid of the conducting triode but blocks it from the grid of the other triode. Suppose, as before, that V1 is cut off and V2 is conducting. The diode side of C3 will carry a potential of about 30 volts (the same as that on the grid of V2). An applied transient will cause this potential to drop momentarily toward 22 volts. CR1 will not conduct since its plate is negative of 22 volts.

However, CR2 will conduct and the negative pulse at the grid of V2 will lower tube current and cause an amplified rise in plate voltage. This rise will carry the grid of V1 above cut-off. The moment V1 conducts, the drop in voltage at its plate, coupled to the opposite grid, re-enforces the negative pulse there. This regenerative action proceeds rapidly until V2 is cut-off and V1 is conducting at a steady rate. The next adequate input pulse causes a reverse action and returns the binary to its original state. Thus, the binary completes a cycle for every two input pulses applied, making it a scale of two. The output is a negative pulse produced by peaking coil L1 when the right triode conducts and its plate voltage drops. This output, consisting of one negative pulse for every two input pulses, is suitable for driving another binary. By connecting binaries in cascade (output of one to input of the next), a counter having a scale of any power of two can be built. A chain of three cascaded binaries would be a scale-of-eight (2^3). If we call the input pulses driving such a chain "counts", the operation may be described as follows. The first binary will produce a negative pulse upon counts 2, 4, 6 and 8. The second binary will generate output pulses at counts 4 and 8, and the third binary will produce a pulse only at count 8. Count 8 completes a full cycle; the binaries will then be in the same state they were in before the first count.

THE SCALE OF TEN

In the Model 795 three binaries are connected in cascade to form a scale of eight. A fourth binary is arranged to block the input to the second binary during two input pulses to the counter, so that ten rather than eight pulses are required to produce a complete cycle. Figure 3 is a block diagram of the circuit.

At the beginning of a cycle the gate control binary is in the state which holds the gate open. For the first three counts (that is, counts 1 thru 3) the unit operates like a simple binary counter. At count 4 the third binary is triggered for the first time and, in turn triggers the gate control binary to its other state, closing the gate. The gate is closed during counts 5 and 6. At count 6 the first binary produces an output pulse which triggers the gate control binary back to the "open" state. During counts 7, 8, 9 and 10 the unit again operates like a simple binary chain. At count 10 the third binary produces a negative output pulse which will drive another decimal counting unit.

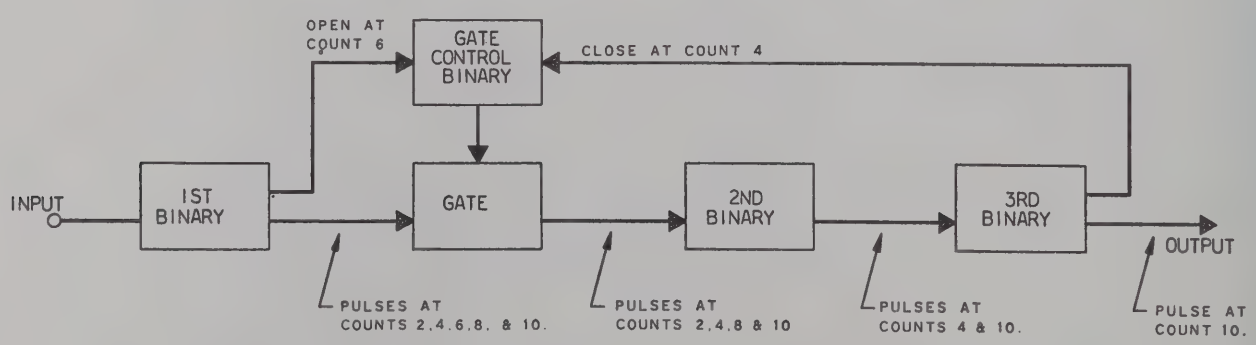


FIGURE 3.

BLOCK DIAGRAM OF MODEL 795 DCU

The operating sequence of the DCU is summarized in Table 1 below which shows the state of each binary for each registered count score. The state of a binary is defined by whether or not triode B is conducting. "0" means triode B is conducting; "1" means triode B is cut off. The "4th" binary is the gate control binary.

TABLE 1

Count Display	State of Each Binary Stage			
	4th	3rd	2nd	1st
0	0	0	0	0
1	0	0	0	1
2	0	0	1	0
3	0	0	1	1
4	1	1	0	0
5	1	1	0	1
6	0	1	0	0
7	0	1	0	1
8	0	1	1	0
9	0	1	1	1
0	0	0	0	0

Figure 4 shows how plate voltages throughout the unit change as successive counts are received. Voltage waveforms are identified by circled numbers corresponding to reference points located on the schematic diagram. The output voltage used to drive succeeding binaries is taken from the junction of a plate load resistor and an RF peaking coil rather than from the plate itself. The waveforms at this junction are negative pulses which occur when plate current increases and plate voltage drops.

The negative pulses, coinciding with negative transients in figure 4, drive succeeding binaries. The gate tube (V105) is driven by negative pulses from the first binary. The gate tube passes the pulse occurring on counts 2, 4, 8 and 10. A negative pulse from the gate at count 6, which would normally reach the second binary, is blocked by the action described in the following paragraph.

At count 4, the third binary switches states. The resulting positive transient at plate B is accompanied by a simultaneous negative transient at plate A. The negative transient, coupled to grid B of the gate control binary, causes this binary to switch to a state in which triode A is conducting. The resulting negative potential at plate A is applied to the grid of triode B in the gate tube. This closes the gate by cutting off triode B, so that the negative pulse generated by the first binary at count 6 cannot reach the second binary. However, this pulse is coupled from the cathode of the gate tube to grid A of the control binary. There, it cuts off triode A, thus returning the control binary to its original stable state and reopening the gate to pass a pulse to the second binary at count 8.

BINARY CODED ELECTRICAL READOUT

The output voltages of each binary are also brought out to pins 2, 6, 9 and 10 of the DCU plug to operate auxiliary binary-coded readout devices. Observe that voltage at pin 6 combines the output of the second binary and the output of triode B of the control binary while the voltage at pin 10 combines the output of the third binary with that of triode A of the control binary. The resultant modified binary code given in Table 2 agrees with that generated by other Beckman instrument. In the table "0" represents a voltage of -12v or more negative with respect to ground; "1" represents a voltage at ground level or positive of ground.

TABLE 2

BINARY READOUT CODE

Count Display	Pin on DCU Plug			
	10th	9th	6th	2nd
0	0	0	0	0
1	0	0	0	1
2	0	0	1	0
3	0	0	1	1
4	0	1	1	0
5	0	1	1	1
6	1	1	0	0
7	1	1	0	1
8	1	1	1	0
9	1	1	1	1
0	0	0	0	0

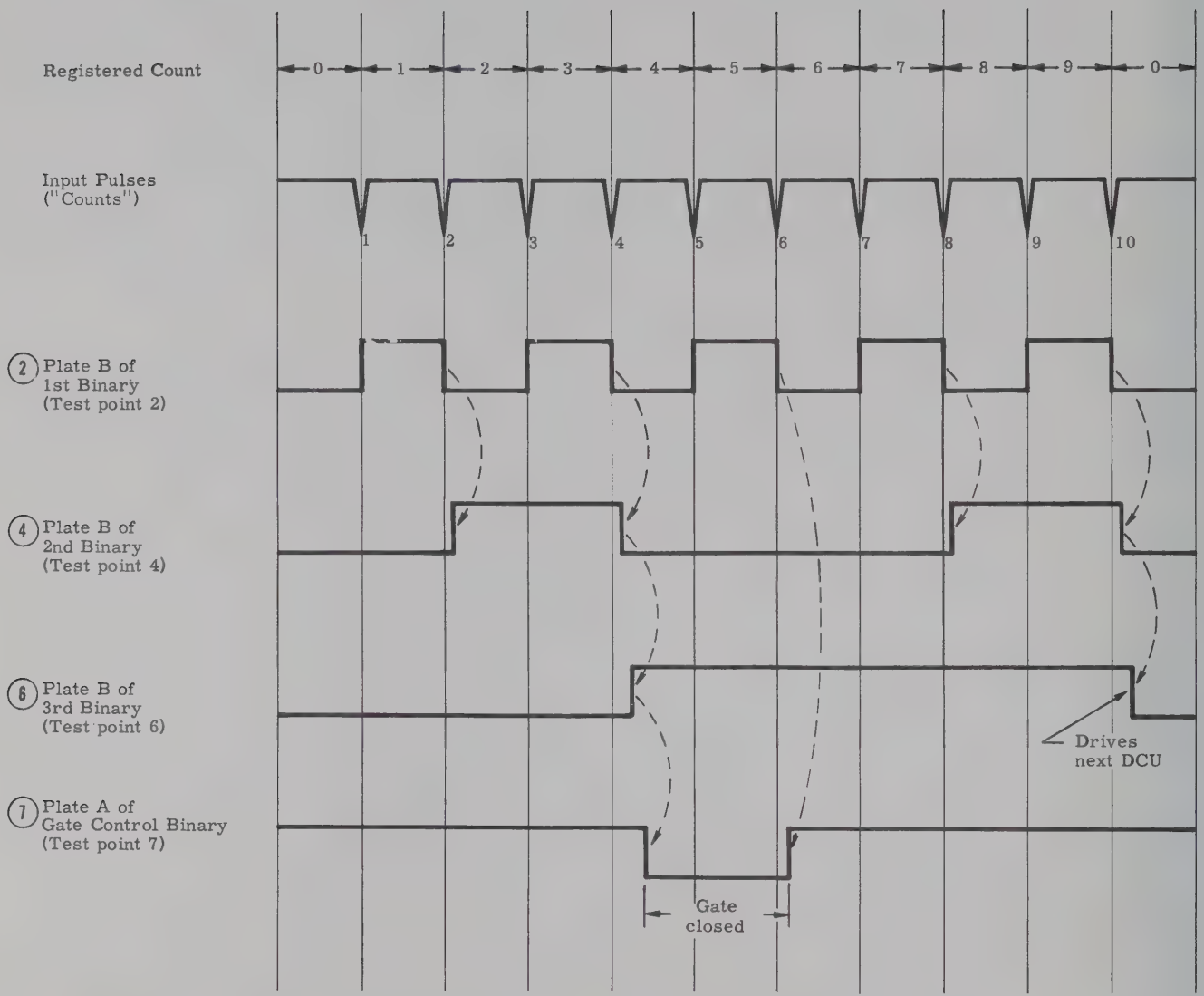


FIGURE 4. IDEALIZED WAVEFORMS.

The negative switching transients trigger succeeding binary stages as indicated by dashed lines. The positive transient at plate B of the 3rd binary is accompanied by a negative transient at plate A which actually triggers the gate control binary. Notice that the gate, although opened by a pulse from the 1st binary at count 6, does not open soon enough to pass this pulse to the 2nd binary. See figure 7 for actual waveforms.

THE DECODING MATRIX

As the DCU cycles from a registered count of 0 through a registered count of 9, ten discreet combinations of binary states are produced. Any particular combination is represented by eight dc voltage levels, one from each plate of each of the four binaries. These voltages are applied to a decoding matrix consisting of a network of resistors, diodes and neon bulbs. The voltages at the plates of the first binary, V101A and V101B, are amplified by V106A and V106B before application to the matrix. The matrix contains a set of "and" gates, constructed in such a way as to apply breakdown potential across a neon bulb only when the combination of dc voltages representing that bulb number occurs.

Table 3 shows the plate voltages applied to the decoding matrix during each of the ten discreet states of the unit. "H" denotes a "high" voltage; that is, the voltage produced at the plate when the triode is cut off. "L" denotes a "low" voltage; that is, the voltage created when the triode is conducting. The "H" voltage is always positive with respect to the "L" voltage, but whether it is actually a higher voltage with respect to ground depends upon at what point the triode plate circuit is grounded. In some triode circuits the B+ point is grounded, so that all plate voltages are negative with respect to ground, the "H" voltage being less negative than the "L" voltage.

Registered Count		0	1	2	3	4	5	6	7	8	9
Binary Code	1st binary (V101)	0	1	0	1	0	1	0	1	0	1
	2nd binary (V102)	0	0	1	1	0	0	0	0	1	1
	3rd binary (V103)	0	0	0	0	1	1	1	1	1	1
	4th binary (V104)	0	0	0	0	1	1	0	0	0	0
To Plate of	Neon Lamp										
V106B	0	To Plate of									
V106A	1	V102B	L*	L*	H	H	L	L	L	L	H	H
V106B	2	V103B	L*	L*	L	L	H	H	H	H	H	H
V106A	3	V102A	H	H	L*	L*	H	H	H	H	L	L
V106B	4	V103B	L	L	L*	L*	H	H	H	H	H	H
V106A	5	V104A	H	H	H	H	L*	L*	H	H	H	H
V106B	6	V102B	L	L	H	H	L	L	L*	L*	H	H
		V103A	H	H	H	H	L	L	L*	L*	L	L
V106A	7	V104B	L	L	L	L	H	H	L*	L*	L	L
V106B	8	V102A	H	H	L	L	H	H	H	H	L*	L*
V106A	9	V103A	H	H	H	H	L	L	L	L	L*	L*

TABLE 3

DECODING SCHEME: BINARY STATES TO DECIMAL DIGITS
See "The Decoding Matrix" for explanation.

For a lamp to light, the plate connected to the left-hand terminal (as shown in the table) must be "high" and all plates connected to the right-hand terminal must be "low". The voltages at the left-hand terminals determine whether an even-numbered or an odd-numbered lamp will light. When the registered count is an even number, the plate of V106B is high and the plate of V106A is low; when the registered count is odd these voltages are reversed. The voltage at the right-hand terminals determine which of the five odd-even pairs (0 & 1, 2 & 3, 4 & 5, 6 & 7 or 8 & 9) will have an opportunity to light. Notice that for any given registered count, only one pair will be connected to plates, all of which are low. These points are marked by an asterisk in the table.

To take an example, suppose the registered count is 3. Searching the column under "3" we find that two low plates (V102A & V103B) are connected to neon pair 2 & 3. This provides the necessary "low" voltage at the right-hand terminals of the bulbs. Since 3 is an odd number, the plate of V106A is high and that of V106B, low. Therefore, neon 3, connected between high and low voltages, lights, whereas neon 2 remains extinguished.

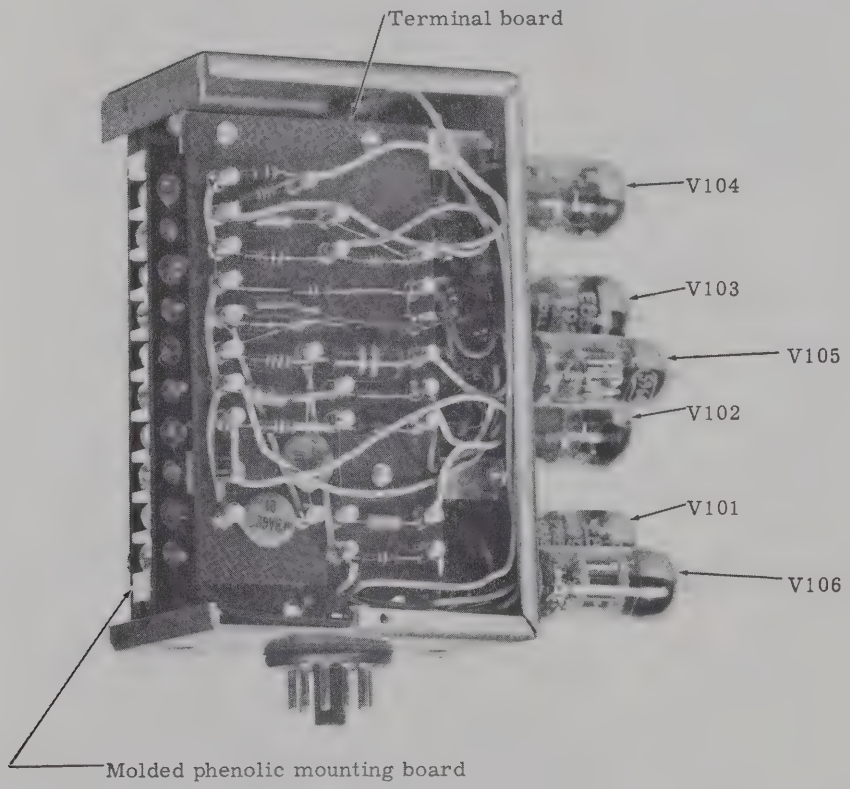


FIGURE 5.

Interior view of counting unit.

SERVICING

When a Decimal Counting Unit is suspected of counting incorrectly, it should be interchanged with a spare unit to determine whether the trouble is in the suspected unit or in the associated circuitry. This test should be made very carefully. Since the counting unit is usually the indicating device of a larger instrument, faulty operation is often ascribed to it when the symptoms of external faults are displayed.

TROUBLESHOOTING

Two methods are recommended for finding the trouble in a faulty counting unit. First, by observing the lighting sequence while driving the unit at a slow repetition rate, and second, by studying the waveform of each stage while driving the unit at a repetition rate fast enough to be conveniently viewed on an oscilloscope. It is impossible to say which method should be used in every case, since marginal failures may occur at high counting speeds and not at lower counting rates, and vice versa. The first method is the only way that a neon lamp failure can be located, and it can be used to locate component and tube failures. For this reason, it is recommended that this method be used first.

The Troubleshooting Chart lists some common troubles which may be readily localized by observing the lighting patterns. Figure 8 shows actual oscilloscope waveforms to be used for comparison. These pictures were taken using an input frequency of 10 megacycles. The waveshapes differ slightly and peak-to-peak voltages are smaller than at lower frequencies. Voltage and resistance measurements at tube pins are given in table 4.

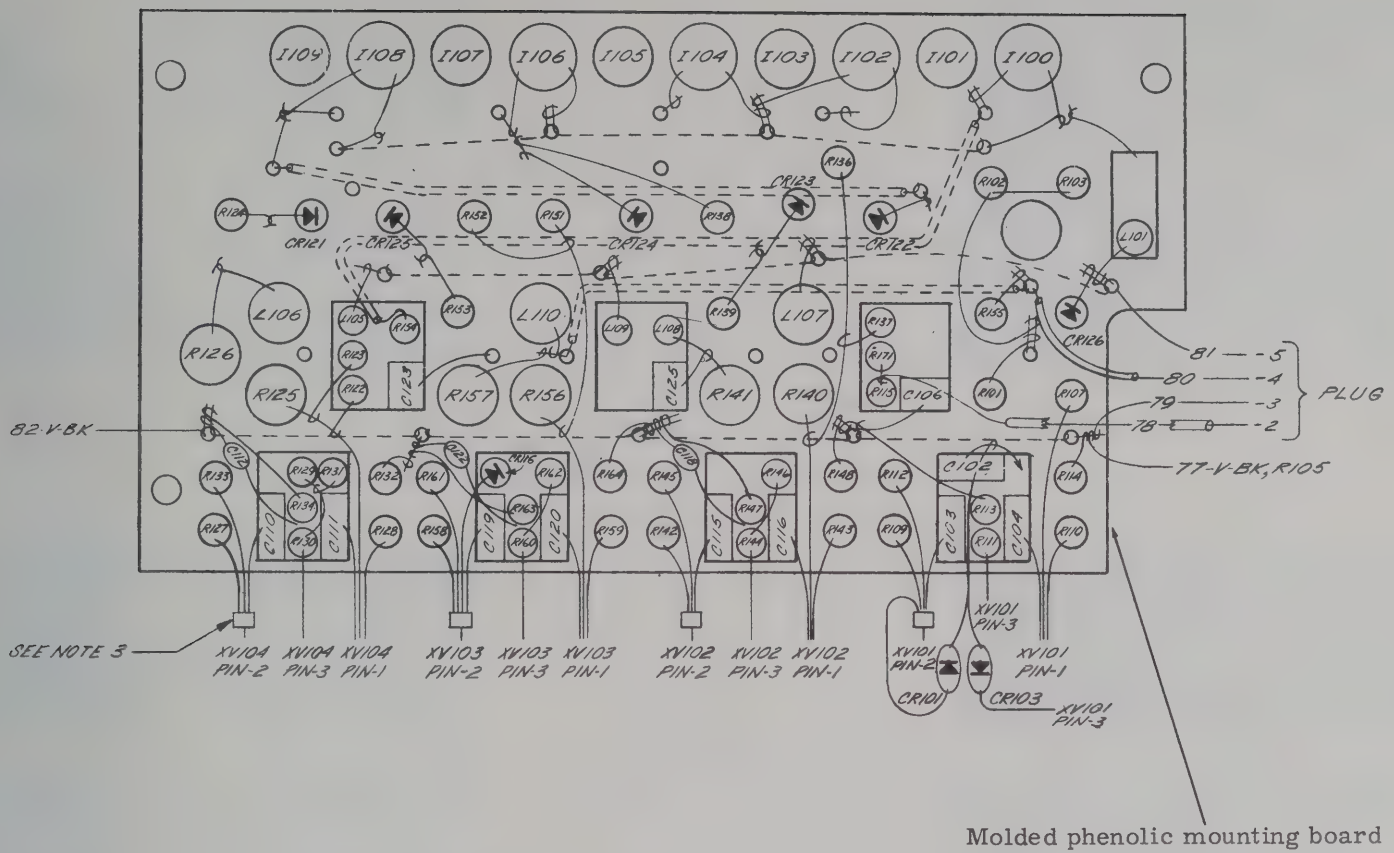
Locating the source of erratic operation is sometimes difficult because a feedback loop from the 3rd binary, through the 4th binary to the 2nd binary, makes all these stages interdependent. A failure in one stage will cause all to misfunction. To facilitate troubleshooting, the feedback loop can be broken by removing the 4th binary tube (V104). The DCU then becomes a simple chain of three binaries, V101, V102 and V103. These binaries form a scale-of-eight, so that if all three are operating correctly the unit will cycle through eight rather than ten discreet states. At slow speeds this produces the indicating sequence 0-1-2-3-6-7-8-9. At higher speeds output waveforms will appear as square waves, each binary producing waves at half the frequency and twice the pulse width of the preceding binary. Since there is no interaction between stages, trouble can be located by straightforward signal tracing.

Trouble in the binary stages (V101 thru V104) can be distinguished from troubles in the decoding circuitry by comparing binary output waveforms with the lighting sequence. If waveforms are correct but lighting sequence is erroneous, trouble lies in the decoding circuitry. It will be found that most failures are caused by faulty tubes or crystal diodes.

TROUBLESHOOTING CHART

NOTE: Reset unit before testing for symptoms.

Symptom	Cause
Unit fails to count	(a) Insufficient supply voltage (b) Input signal of insufficient amplitude (c) Input signal of wrong polarity (d) First binary stage inoperative
Unit counts spuriously without input signal	(a) Stray input signal (b) Pulses received through power supply
Unit counts erratically	(a) Input signal too large or small, incorrect rise time (b) Supply voltage fluctuating too much
Unit fails to reset	(a) Stray counts from reset switch or associated circuitry (b) Defective component
Unit counts in wrong sequence	
1. Skips every other number	(a) First binary stage (V101) defective (b) Input circuit supplies double pulses
2. Skips 4 and 5	(a) 4th binary stage (V104) not being driven by the 3rd (V103)
3. Skips 6 and 7	(a) Gate tube (V105) not being driven by V104
Repeats a pattern of numbers	
1. Two stable states per cycle (0-1 or 2-3, etc.)	(a) 2nd binary stage (V102) not being driven (b) Defective gate tube (V105)
2. Four stable states per cycle (0-1-2-3 or 6-7-8-9)	(a) 3rd binary stage (V103) not being driven
3. Counts up to 5, then alternates between 4-5	(a) 4th binary stage (V104) not being driven by the 1st (V105)
Two or more lamps light simultaneously	Defective amplifier stage (V106)
Skips one number on indicator but binary-coded output count is correct	Defective neon lamp



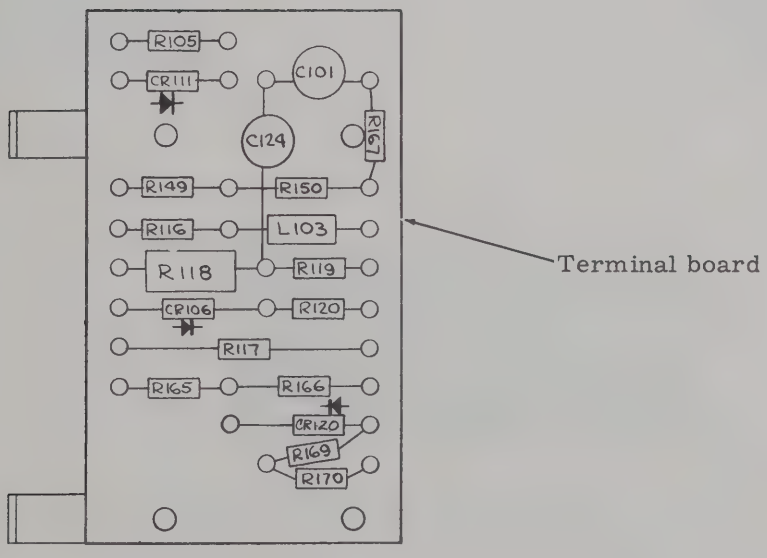
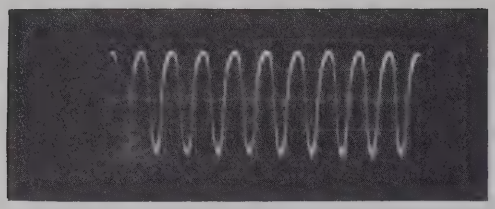
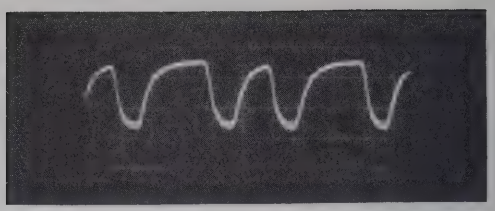


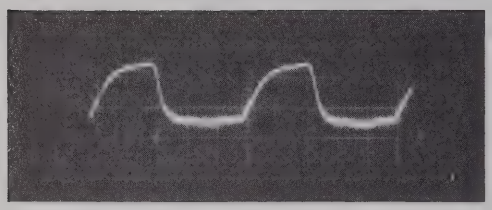
FIGURE 6.
PARTS LOCATION



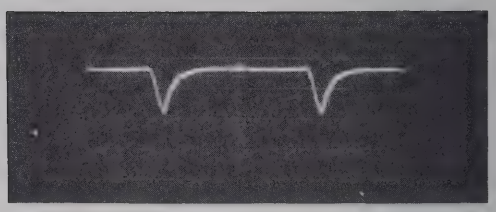
(1) 1st binary, plate A
V101, pin 1
10v/em, 0.2μsec/cm
Top grid line is ground level.



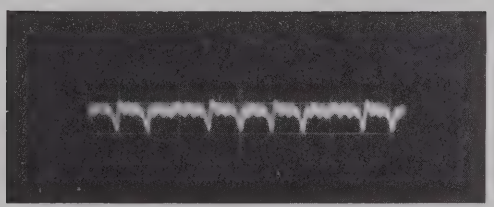
(3) 2nd binary, plate A
V102, pin 1
20v/cm, 0.2μsec/cm
Top grid line is ground level.



(5) 3rd binary, plate A
V103, pin 1
20v/cm, 0.2μsec/cm
Top grid line is ground level.



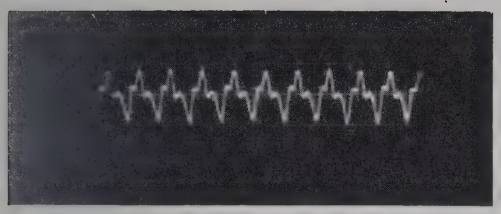
(7) Gate control binary, plate A
V104, pin 1
20v/cm, 0.2μsec/cm
Top grid line is ground level.
Gate is closed by negative pulse.



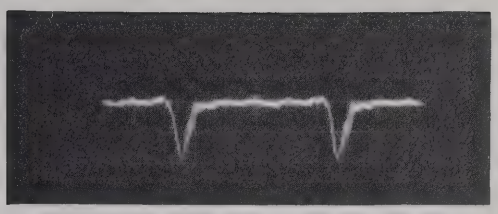
(9) Gated pulses to 2nd binary
V105, pin 1
5v/cm, 0.2μsec/cm, Scope ac-coupled.
Picture shows two complete DCU cycles starting with a registered count of zero. Negative pulses occur at counts 2, 4, 8 & 10. No pulse occurs at count 6.

FIGURE 7a

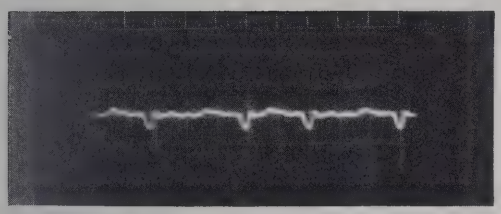
Typical waveforms with input frequency of 10Mcs.
Each picture shows two complete DCU cycles
starting from a registered count of zero.



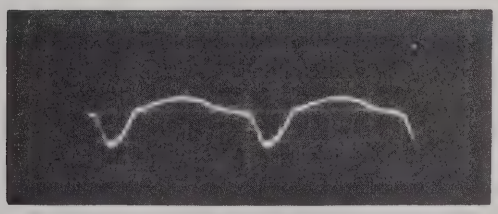
Gate signal to gate control binary
V105, pin 7
5v/cm, 0.2μsec/cm, Scope ac-coupled.
Negative pulses occur every even-numbered count.
Pulse at count 6 triggers control binary.



Gating signal at gate
V105, pin 6
5v/cm, 0.2μsec/cm
Grid line second from top is ground level.
Gate is closed when voltage at this point is -10v or more negative with respect to ground.



Drive pulses to 3rd binary.
Junction of L108 & R141.
5v/cm, 0.2μsec/cm
Center horizontal grid line is ground level.
Pulses occur at counts 4 and 10.



Output of DCU
P101, pin 4
5v/cm, 0.2μsec/cm
Negative transients drive next DCU.

FIGURE 7b

Typical waveforms with input frequency of 10Mcs.
Each picture shows two complete DCU cycles
starting from a registered count of zero.

VOLTAGES

Table 4a

Note: Voltages measured to ground at registered count "0" with a vacuum tube voltmeter such as an RCA Volt-ohmyst Senior. B+ voltage is 120 volts. B- voltage is -110 volts. Voltages may vary ±10% due to component tolerances and tube variations.

Tube	Voltages at Tube Pin								
	1	2	3	4	5	6	7	8	9
V101	-3.5	-90	-85	Fil	Fil	-35	-85	-85	-85
V102	-6.5	-90	-85	Fil	Fil	-50	-85	-85	-85
V103	-9	-90	-85	Fil	Fil	-54	-85	-85	-85
V104	-6.5	-90	-85	Fil	Fil	-50	-85	-85	-85
V105	+96	+96	Fil	Fil	0	-5	0		
V106	+20	-7.5	Fil	Fil	-2.5	-35	-25		

RESISTANCES

Table 4b

Note: Resistances are measured to chassis ground with the DCU removed from its socket. Where path to ground goes through a diode, resistance reading depends upon polarity and magnitube of voltage applied by ohmmeter. These readings taken with RCA Volt-ohmyst Senior with negative terminal to chassis ground. Applied voltage was approximately 1.5v.

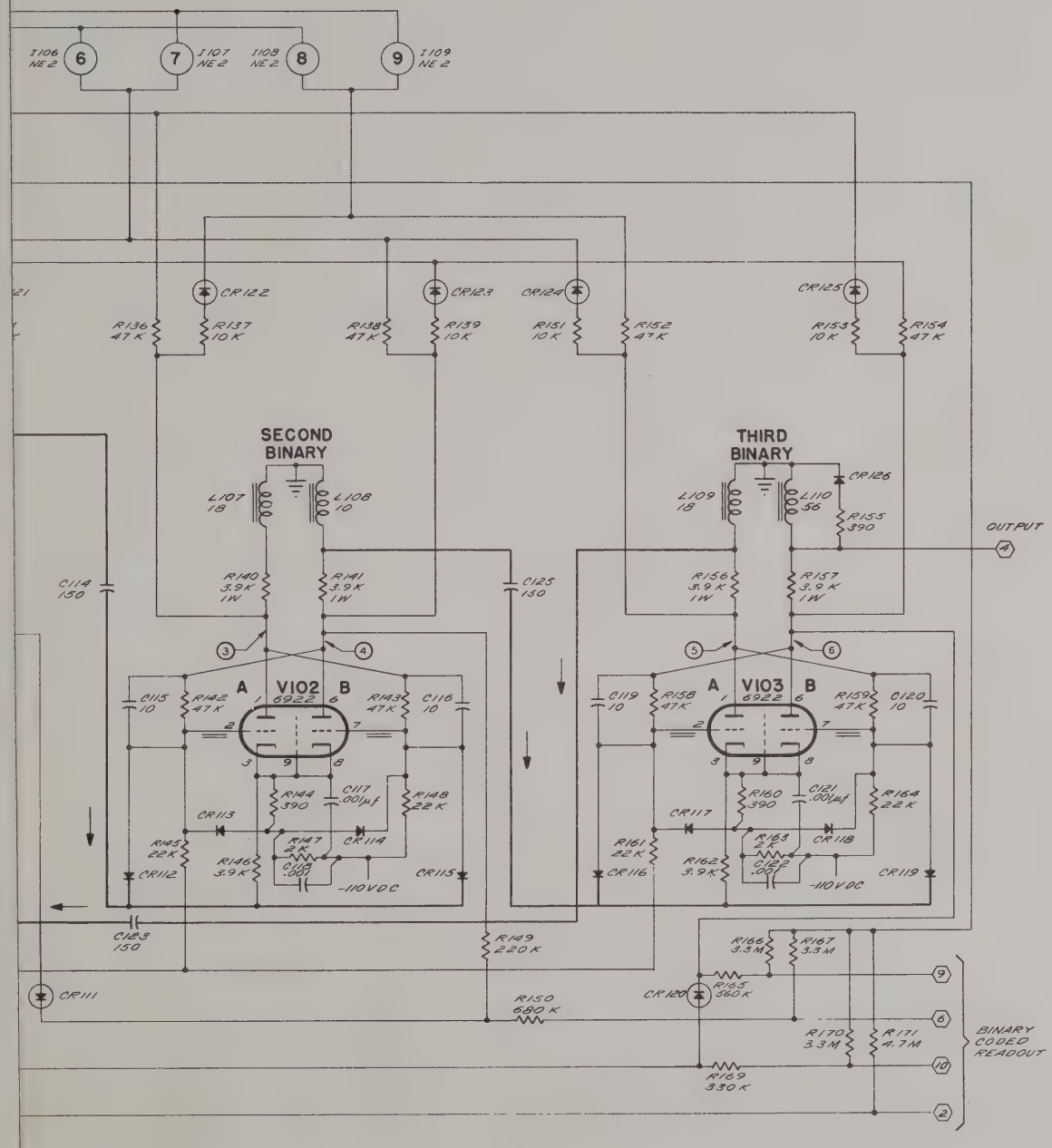
Tube	Resistances at Tube Pin								
	1	2	3	4	5	6	7	8	9
V101	2.1K	9.6K	7.5K	∞	∞	2.1K	9.6K	7.5K	7.5K
V102	3.9K	10.5K	7.8K	∞	∞	3.9K	10.5K	7.8K	7.8K
V103	3.9K	10.5K	7.8K	∞	∞	3.9K	10.5K	7.8K	7.8K
V104	3.2K	10.5K	8K	∞	∞	3.9K	10.5K	8K	8K
V105	100K	100K		∞	0	3.1K	20K		
V106	300K	300K		∞	110K	110K	135K		

PARTS LIST

This list includes all electrical parts except resistors. All resistors are Allen-Bradley fixed composition types of the value, power rating and tolerance noted on the schematic diagram.

Detail No.	Beckman Stock No.	Description	Manufacturer & Manufacturer's No.
C101	2-4388	Cap., .01μfd, disc, axial leads	Sprague 59929
C102	2-1939	Cap., 20μμfd, 500v dc, silvered mica	Sangamo RR 1420
C103	2-2082	Cap., 10μμfd, 500v dc, silvered mica	Sangamo RR 1410
C104		Same as C103	
C105	2-2608	Cap., 300μμfd, 300v dc, silvered mica	Sangamo RR 1330
C106		Same as C105	
C107	2-5491	Cap., 150μμfd, 500v dc, silvered mica	Sangamo RR 1315
C108	2-2136	Cap., 100μμfd, 500v dc, silvered mica	Sangamo RR 1310
C109	2-3508	Cap., 6.8μμfd, 600v dc, ceramic tubular	Erie GP1K
C110 & C111		Same as C103	
C112	2-5793	Cap., .001μfd, disc	Centralab DD102
C113		Same as C112	
C114		Same as C107	
C115 & C116		Same as C103	
C117 & C118		Same as C112	
C119 & C120		Same as C103	
C121 & C122		Same as C112	
C123		Same as C107	
C124		Same as C101	
C125		Same as C107	
CR101	8-7274	Diode, 1N198	Amperite
CR102 thru CR110		Same as CR101	
CR111	8-7547	Diode, HD-6237	BDB 795 A 7
CR112 thru CR119		Same as CR101	
CR120 thru CR125		Same as CR111	
CR126		Same as CR101	
I100	21-0426	Lamp, NE 2	GE
I101 thru I109		Same as I100	
L101	3-7330	Choke, 18μh, molded	Nat. Coil QA-18-I
L102	3-7512	Choke, 12μh, molded	Nat. Coil NA-12-I
L103	3-7332	Choke, 10μh, molded	Nat. Coil NA-10-I
L104		Same as L103	
L105 thru L107		Same as L101	
L108		Same as L103	
L109		Same as L101	
L110	3-7333	Choke, 56μh, molded	Nat. Coil RA-56-I
	3-7251	Shielding Bead	Ferroxcube Corp. 255T118A205

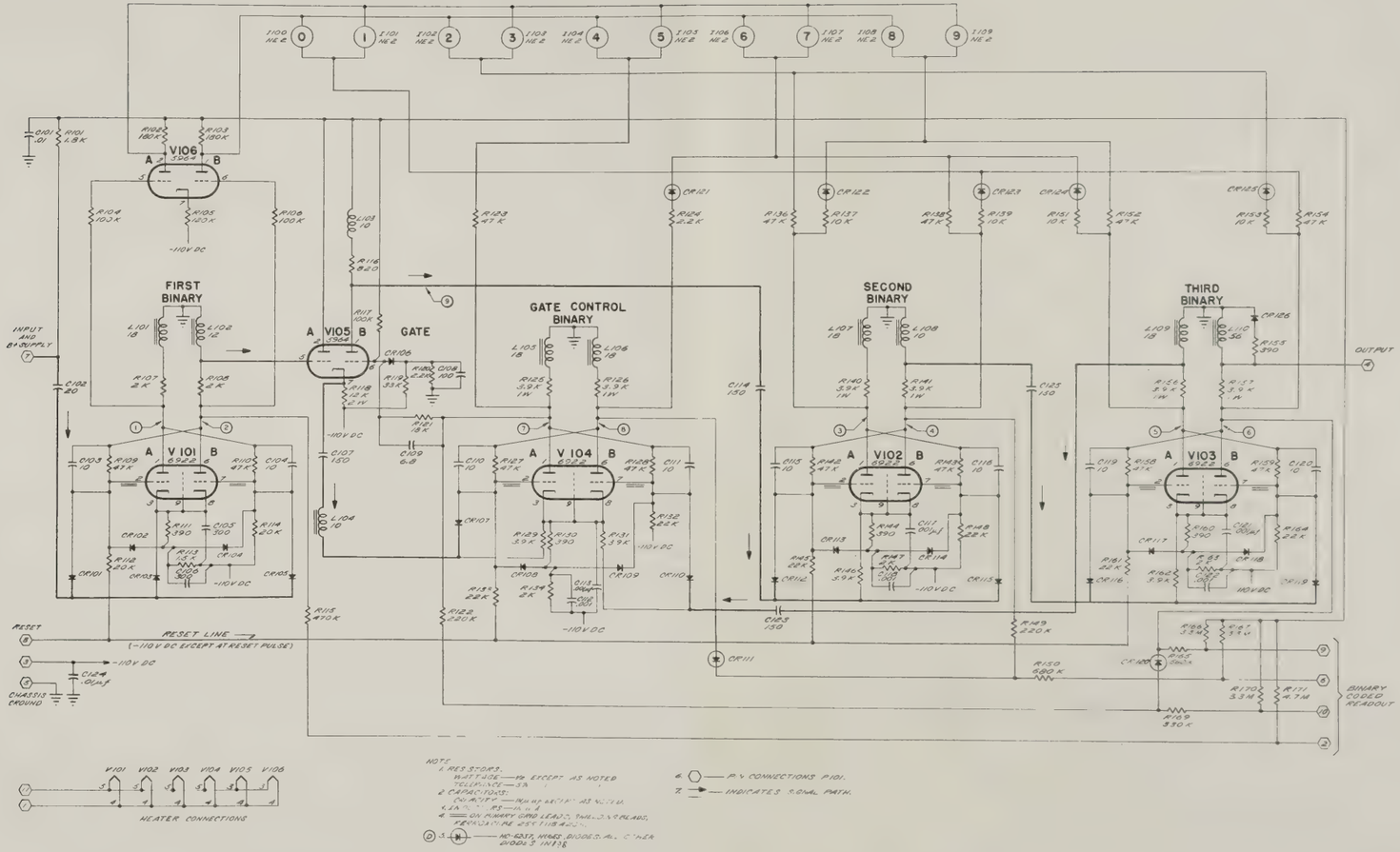
Detail No.	Beckman Stock No.	Description	Manufacturer & Manufacturer's No.
P101	17-1719	Connector, 11-pin, octal style	Amphenol 86-CP11
V101	5-4764	Tube, 6922	Amperex
V102 thru V104		Same as V101	
V105	5-2494	Tube, 5964	RCA
V106		Same as V105	
XV101	4-6508	Socket, 9-pin, w/o tube shield, w/center socket shield	Elco 274
XV102 thru XV104		Same as XV101	
XV105	4-6509	Socket, 7-pin, w/o tube shield, w/center socket shield	Elco 108
XV106		Same as XV105	



SCHEMATIC DIAGRAM
MODEL 795
DECIMAL COUNTING UNIT

August 1959

Detail No.	Beckman Stock No.	Description	Manufacturer & Manufacturer's No.
P101	17-1719	Connector, 11-pin, octal style	Amphenol 86-CP11
V101	5-4764	Tube, 6922	Amperex
V102 thru V104		Same as V101	
V105	5-2494	Tube, 5964	RCA
V106		Same as V105	
XV101	4-6508	Socket, 9-pin, w/o tube shield, w/center socket shield	Elco 274
XV102 thru XV104		Same as XV101	
XV105	4-6509	Socket, 7-pin, w/o tube shield, w/center socket shield	Elco 108
XV106		Same as XV105	



NOTE:
1. RESISTORS:
WATTAGE — 1/2 W, EXCEPT AS NOTED.
TOLERANCE — 5%.
2. CAPACITORS:
CAPACITY — IN MICROFARADS (μF) AS NOTED.
VOLTAGE — 25 V, EXCEPT AS NOTED.
4. ⏚ ON PRIMARY GRID LEAD: 2 MEG, 3 V 0 BIAS, FREQUENCY RESPONSE COMPENSATING.
5. CR101 THROUGH CR119 — HD-6337, HYCOR DIODES. ALL OTHER DIODES 1N198.

SCHEMATIC DIAGRAM
MODEL 795
DECIMAL COUNTING UNIT

August 1959

INSTRUCTION MANUAL

DECIMAL COUNTING UNIT

MODEL 705B

and Modifications

Lot No. ___

Berkeley division
Beckman Instruments, Inc.

Richmond 4, California
9 December 1957

WARRANTY

Instruments sold by Berkeley Division, Beckman Instruments, Inc., (hereafter called "the Company") are warranted only as stated below.

Subject to the exceptions and upon the conditions specified below, the Company agrees to correct, either by repair, or, at its election, by replacement, any defect of material or workmanship which develops within one year after delivery of the instrument to the original purchaser by the Company or by an authorized representative, provided that investigation and factory inspection by the Company discloses that such defect developed under normal and proper use.

The exceptions and conditions mentioned above are the following:

(a) Some components and accessories by their nature are not intended to, and will not, function one year. If any such component or accessory manufactured by the Company and part of the item sold fails to give reasonable service for a reasonable period of time, the Company will, at its election, replace or repair such component or accessory. What constitutes reasonable service and what constitutes a reasonable period of time shall be determined solely by the Company after the Company is in posession of all the facts concerning operating conditions and other pertinent factors and after such component or accessory has been returned to the Company, transportation prepaid.

(b) All instruments claimed defective must be returned to the Company, transportation charges prepaid, and will be returned to the customer with the transportation charges collect, unless the item is found to be defective in which case the Company will pay all transportation charges.

(c) The Company makes no warranty concerning components or accessories not manufactured by it, such as tubes, fuses, batteries, etc. However, in the event of the failure of any component or accessory not manufactured by the Company, the Company will give reasonable assistance to the purchaser in obtaining from the respective manufacturer whatever adjustment is reasonable in the light of the manufacturer's own warranty.

(d) Except as stated above, the Company makes no warranty, express or implied (either in fact or by operation of law), statutory or otherwise; and, except to the extent stated above, the Company shall have no liability under any warranty, express or implied (either in fact or by operation of law), statutory or otherwise.

(e) The Company expressly disclaims any liability to its customers, dealers, and to users of its products, and to any other person or persons for consequential damages of any kind and from any cause whatsoever arising out of or in any way connected with the manufacture, sale, repair, replacement of, or arising out of or in any way connected with the use of any of its products.

(f) Representations and warranties made by any person, including representatives of the Company, which are inconsistent or in conflict with the terms of this warranty (including but not limited to the limitation of the liability of the Company as set forth above) shall not be binding upon the Company unless reduced to writing and approved by an officer of the Company.

(g) This warranty shall be governed by the laws of the State of California.

Claims for damage in shipment should be filed promptly with the transportation company.

All correspondence concerning the instrument should specify the model and serial number. This information appears on the company name plate. Any inquiry concerning details of operation, possible modifications, etc., should be addressed to the Sales Department, Berkeley division of Beckman Instruments, Inc., Richmond 4, California.

REPAIR SERVICE

Experienced service personnel and special test equipment are available at the factory to perform any necessary repairs. Every effort will be made to expedite the repair of instruments returned for servicing. Repair work will be performed only upon receipt of a written purchase order or authorization. Instruments to be repaired should be addressed to SERVICE AND REPAIR DEPARTMENT with transportation charges prepaid. Repaired instruments will be returned to the purchaser with transportation charges collect.

Berkeley reserves the right to make changes in design at any time without incurring any obligation to modify equipment previously purchased to conform to subsequent design changes.

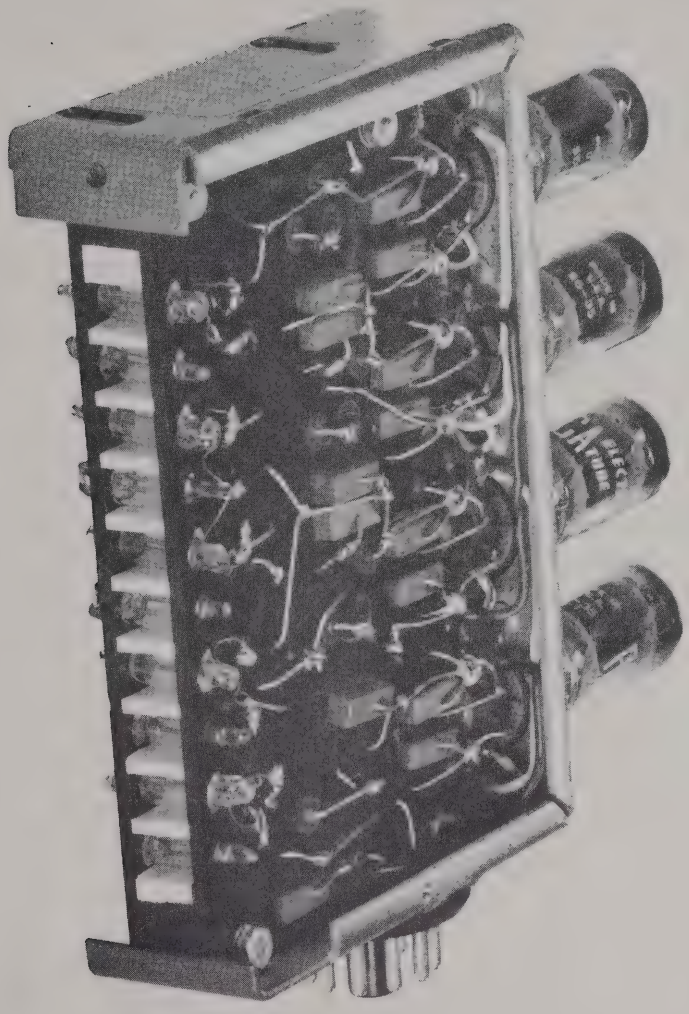
BERKELEY DIVISION
BECKMAN INSTRUMENTS, INC.

INSTRUCTION MANUAL REVISION

Models affected:

605	730A	7151
705A	903	7161
705AH	2020	7351
705AJ	2200	7361
705B	4904	7410
706A	5001	7420

Delete all references to tube type 7316



MODEL 705B DECIMAL COUNTING UNIT
With Side Covers and Indicating Panel Removed

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1. INTRODUCTION

1.1 General Description. This decimal counting unit is a direct-reading, plug-in electronic counter. The number of input pulses received is indicated by the illumination of one of ten neon lamps placed behind a numbered acetate panel. Each unit counts from zero to nine, the tenth pulse resetting the counter to zero and simultaneously generating an output signal. Any number of these units can be connected in cascade (the output of one unit driving the next) forming a counter whose total count capacity depends only on the number of DCU's. Thus, five units will count to 99, 999 resetting to "00, 000" on the 100, 000th pulse.

1.2 Differences between Models. Modifications of Model 705B are designated by an additional letter or letters placed at the end of the model number; for example, 705BJ, 705BK, etc. A modified unit can be identified by this number which will be found stamped on top of the chassis. If you have a modified unit, consult the section on modifications before reading further; the remainder of the manual describes a standard 705B. In general, modifications do not affect the basic design or operation of the unit, but only certain particulars such as method of resetting, whether the indicator lights are illuminated during the counting period, and similar details of operation.

1.3 Technical Characteristics.

Count Indication:

Direct reading, decimal presentation.

Power Requirements:

Heaters: 6.3 v. at 1.2 amps.
Plates: 300 v. at 1.5 ma.

Input Requirements:

Negative pulses (See "Operation").

Output Characteristics:

Designed to drive a Model 705B DCU or any modification thereof. Will also drive a 705A DCU or any modification of it.

Resolution of Paired Pulses:

5 microseconds.

Reset:

Will reset to either zero or nine depending on polarity of reset pulse applied.

Maximum Counting Rate:

100, 000 counts per second.

Construction:

Plug-in, 11-pin socket.

2. OPERATION

2.1 Power Requirements. The heaters require 6.3 volts ac at 1.2 amperes. The unit is designed to operate on a plate voltage of 300 v ±10%. At 300 v it draws 15 ma. Plate voltage may be applied in the form of B+ and B- voltages. The dc level of all output voltages will depend upon the level of the plate supply voltages.

2.2 Input Requirements. The unit can be driven by an 80-volt negative transient with a rise time 1.0 microseconds (measured between 10 and 90 percent values). With greater input amplitude, the rise time may be correspondingly slower.

2.3 Output Characteristics. The output is the rectangular waveform shown in Figure 3. As every tenth input pulse triggers the unit from count display "9" to count display "0", a negative transient occurs at pin 4 of the DCU plug. With a plate supply of 300 volts, the potential at pin 4 drops from +135 to +55 volts with respect to B-. This transient has a rise time of approximately 1.0μsecond, measured between 10 and 90 percent values. It can be used to drive succeeding decimal counting units or other circuitry. The load impedance connected between the output terminal and ground must not be less than 300K or 6K in series with 100 micro-microfarads.

2.4 Method of Resetting after a Counting Period. The unit can be reset to a registered count of either zero or nine by the application of a voltage pulse of the proper polarity: a negative pulse at pin 8 resets it to zero; a positive pulse, to nine. The reset pin should be maintained at the B- supply voltage except when a reset pulse occurs. A 50-volt pulse at least 3μseconds wide is adequate. A 100-volt pulse need be only 1.5μseconds wide. There is no maximum pulse width; however, the DCU will not begin counting again until the reset pin returns to the B- supply voltage.

Simply disconnecting the reset pin from B- with a switch or relay will have the same effect as applying a positive pulse.

2.5 Binary Code Readout. The unit generates a modified binary code representing the decimal digit registered. The code appears in the form of a voltage (high or low) at one plate of each of four double-triode binaries. In the table below, "0" represents a plate voltage of approximately +55 volts with respect to B-; "1" represents a plate voltage of about +135 volts with respect to B-. (These are the voltage levels which appear when using a 300-volt plate supply.) Each of the four plates is coupled to a pin of the DCU plug through a 1.2 megohm resistor.

DECIMAL DIGIT REGISTERED	FOUR - LINE BINARY CODE			
	1st Binary Stage (Pin 2 of DCU plug)	2nd Binary Stage (pin 6 of DCU plug)	3rd Binary Stage (Pin 9 of DCU plug)	4th Binary (Pin 10
0	0	0	0	0
1	1	0	0	0
2	0	1	0	0
3	1	1	0	0
4	0	1	1	0
5	1	1	1	0
6	0	0	1	1
7	1	0	1	1
8	0	1	1	1
9	1	1	1	1

3. CIRCUIT DESCRIPTION

3.1 The Binaries. The decimal counting units contain four "flip-flop" circuits. These circuits are slightly modified versions of the Eccles-Jordan trigger circuit. They are referred to here as binaries.

Figure 1 is a schematic diagram of a typical binary. It consists of two triode voltage amplifiers with the plate of each direct-coupled to the grid of the other. With no input this circuit assumes one of two stable states: V1 conducting steadily and V2 cut off, or V2 conducting and V1 cut off. Suppose V1 is not conducting. Then, its plate is near the B-voltage. A portion of this voltage, applied to the grid of V2 through the voltage dividing network R5 and R8, raises this grid above cut-off and permits V2 to conduct. While V2 is conducting, the low positive potential at its plate, coupled to the grid of V1 through the dividing network R4 and R6, holds this grid several volts below cut-off. Since small changes in the potential at the grid of V1 will not raise it above cut-off, this state is stable and will persist until disturbed by an appreciable input signal. Notice that, since the circuit is symmetrical, the opposite state is equally stable.

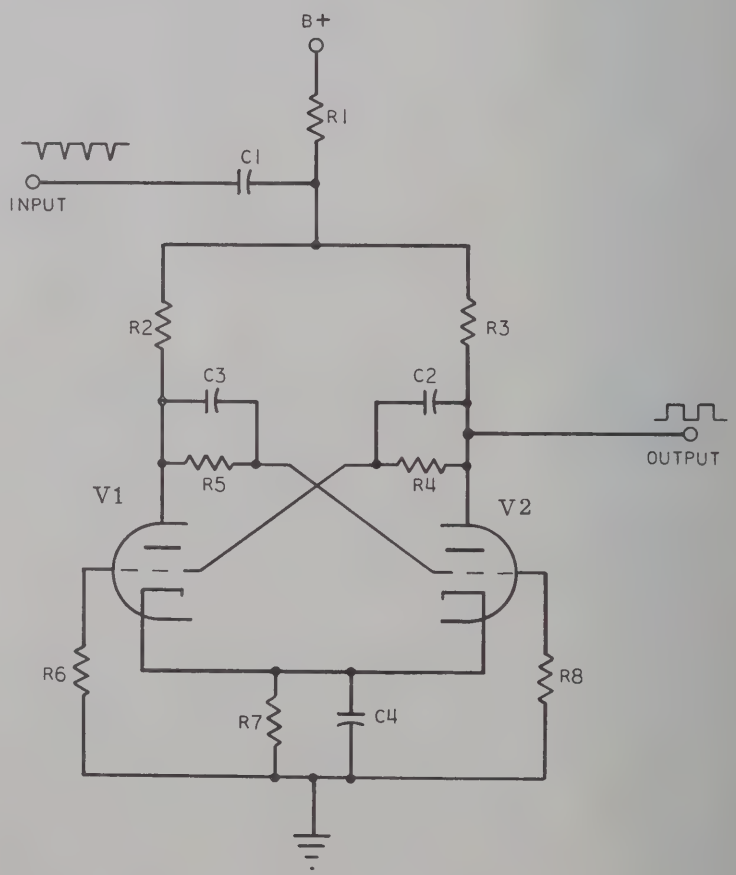


Figure 1. A Typical Binary

The circuit is triggered from one state to another by negative transients applied at the input. For example, assume that V2 is conducting and V1 is cut off. If a negative transient is applied to the input, there is a drop in the plate voltage of V1. This drop in voltage is transmitted through a crossover network (R5, R8, C3 and the grid-to-ground capacitance of V2) and applied to the grid of V2. The plate voltage of V2 then starts to rise, carrying with it the grid of V1. If the input pulse is of sufficient amplitude, V1 begins to conduct. The moment V1 conducts, the drop in voltage at its plate, coupled to the grid of V1, reinforces the negative transient there. This regenerative action proceeds rapidly until V2 is cut off and V1 is conducting at a steady rate. The next adequate input transient causes a reverse action and returns the binary to its original state. Thus, the binary completes a cycle for every two input transients applied, making it a scale-of-two. The output is the drop in voltage at one of the plates as that triode begins to conduct. This output, consisting of one negative transient for every two input transients, is suitable for driving another binary.

By connecting binaries in cascade (output of one to input of the next) a counter having a scale of any power of two can be built.

3.2 The Scale of Ten. To form a decimal counting unit four binaries are connected in cascade forming a scale-of-16 which is permuted to a scale-of-10 by two feedback paths. (See Figures 2 and 3.) For the first three negative input pulses, the unit operates like a simple binary counter. At the fourth input pulse, the third binary is triggered for the first time, sending a pulse through the first feedback path which triggers the second binary. Since it requires two input pulses to trigger the second binary, this is equivalent to adding two input pulses; therefore, the state of the unit now corresponds to a binary count of six. The sixth input pulse (equivalent to the eighth in a simple binary chain) triggers the fourth binary which sends a pulse through the second feedback path, triggering the third binary. This is equivalent to adding four more input pulses so the state of the unit now corresponds to a binary count of 12. For the next four input pulses (7 thru 10) the unit operates again as a simple binary chain, producing an output pulse at the tenth input pulse. Adding the equivalent of six input pulses internally has changed the binary chain from a scale-of-16 to a scale-of-10.

When the third binary is triggered by a feedback pulse, it tends to retrigger the second binary in the same way that it did at the time of input pulse four. This tendency is offset by a simultaneous opposing signal from the fourth binary.

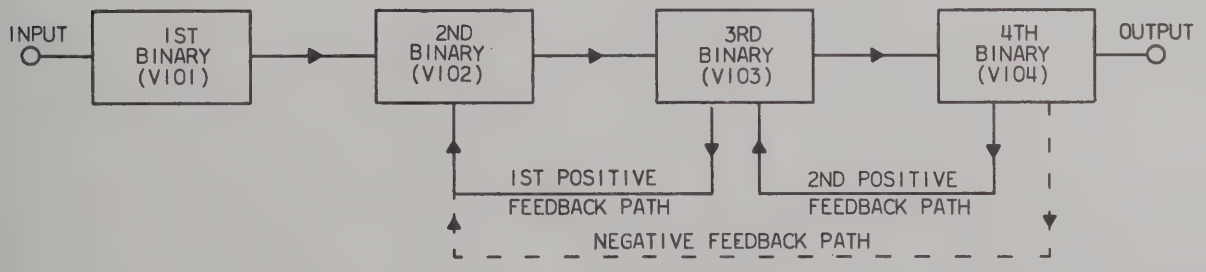


Figure 2. Block Diagram

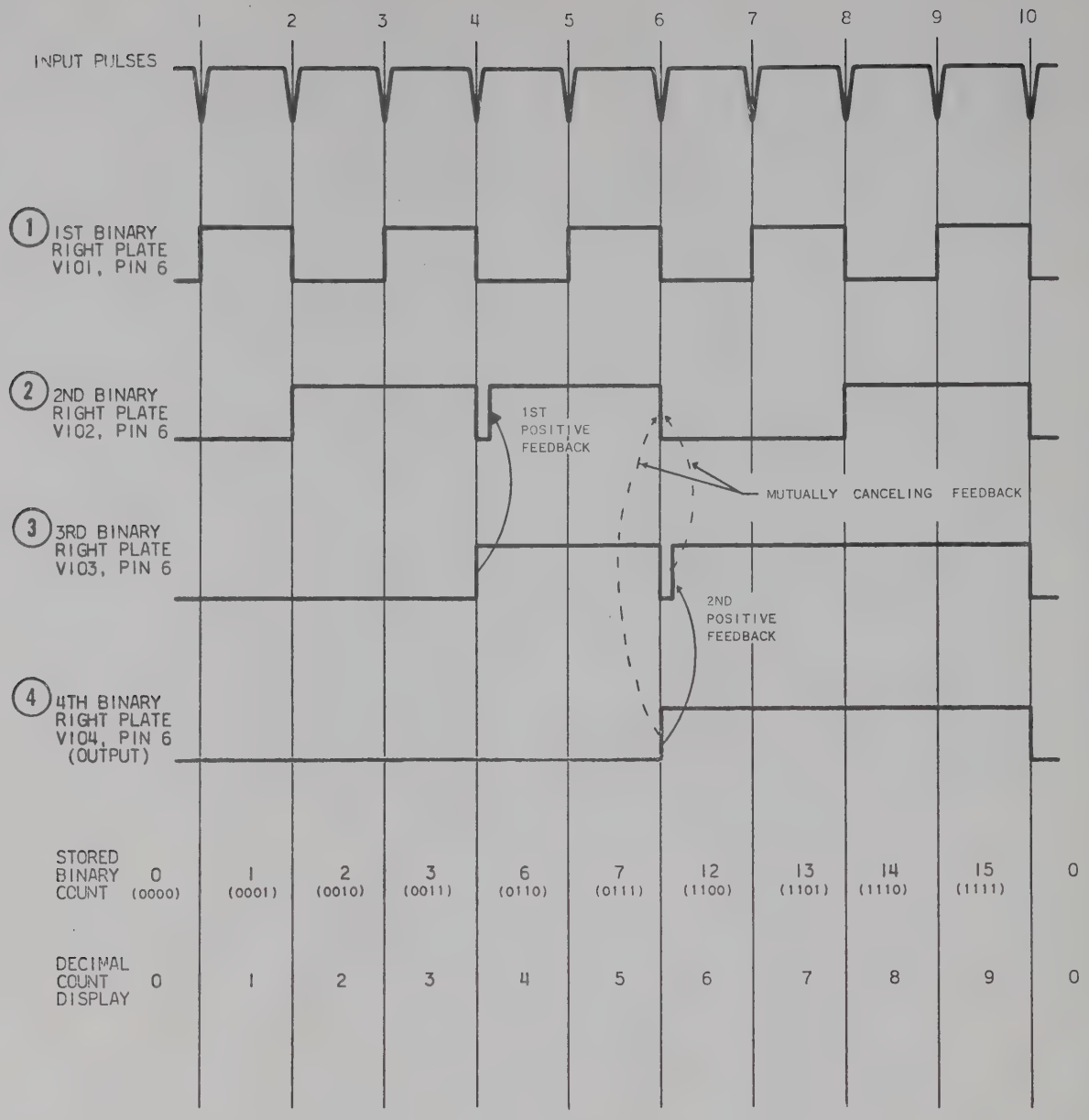

1 2 3 4 5 6 7 8 9 10
INPUT PULSES
1 1ST BINARY RIGHT PLATE V101, PIN 6
2 2ND BINARY RIGHT PLATE V102, PIN 6
3 3RD BINARY RIGHT PLATE V103, PIN 6
4 4TH BINARY RIGHT PLATE V104, PIN 6 (OUTPUT)
1ST POSITIVE FEEDBACK
MUTUALLY CANCELING FEEDBACK
2ND POSITIVE FEEDBACK
STORED BINARY COUNT 0 (0000) 1 (0001) 2 (0010) 3 (0011) 6 (0110) 7 (0111) 12 (1100) 13 (1101) 14 (1110) 15 (1111) 0
DECIMAL COUNT DISPLAY 0 1 2 3 4 5 6 7 8 9 0

Figure 3. Idealized Waveforms. "Right Plate" refers to the plate appearing on the right-hand side of the binary as drawn on the schematic.

4. SERVICING

4.1 General Troubleshooting Procedure. When a decimal counting unit is suspected of counting incorrectly, it should be interchanged with another unit in the instrument or replaced with a spare unit to determine whether the trouble is in the suspected unit or in the associated circuitry. This test should be made very carefully. Because the counting unit is usually the indicating device of an instrument, it is often accused of operating incorrectly when the fault is external to it.

Two methods are recommended for locating a defect in a DCU. The first is to observe the lighting sequence while driving the unit at a slow pulse rate.

The second is to study the output waveform of each binary while driving the unit fast enough to create an oscilloscope display. It is impossible to say which method should be used in every case, since marginal failures may occur at high counting speeds and not at lower counting rates, and vice versa. The first method is the only way that a neon lamp failure can be located, and it can be used to locate component and tube failures. For this reason, it is recommended that this method be used first. The table of common troubles lists the probable defects indicated by particular variations from the proper lighting sequence. Binary output waveforms may be compared with the idealized waveforms of Figure 3 and the photographs appearing in Figure 4.

A table of typical voltages and resistances has been provided to help the serviceman locate a defect within one of the binary stages. Values may deviate considerably from those given without causing trouble. The fact that the unit is designed to operate at plate supply voltages ranging from 200 to 400 volts is a rough indication of permissable tolerances.

4.2 TABLE OF SYMPTOMS WITH PROBABLE CAUSES

NOTE: Reset unit to zero before testing for symptoms

SYMPTOMS	POSSIBLE CAUSES
Unit Fails to Count	(a) Insufficient supply voltage. (b) Input signal of insufficient amplitude. (c) Input signal of wrong polarity. (d) First stage inoperative.
Unit Counts Spuriously	(a) Extraneous input signals. (b) Pulses received through power supply. (c) External voltages picked up by output lead.
Unit Counts Erratically	(a) Input signal too large or small, incorrect rise time. (b) Supply voltage fluctuating too much.
Unit Fails to Reset	(a) Stray counts from reset switch or associated circuitry. (b) Defective component.
Unit counts regularly but neon bulbs light in wrong sequence and the pattern of lighting is repeated consistently after a definite number of input pulses. One or more bulbs may be lit simultaneously during a cycle but the number of states per cycle remains constant.	
1. Unit skips every other number	(a) First stage defective. (b) Input circuit supplies double pulses.
2. Two stable states per cycle.	(a) Second stage defective (display sequence may be 01 or 45). (b) Loss of drive to second stage (01).
3. Four stable states per cycle.	(a) Third stage defective (display sequence may be 0123 or 6789). (b) Loss of drive to third stage (0123).

4. Six stable states per cycle.

(a) Output excessively loaded (display sequence may be 012345).

(b) Last stage inoperative (display sequence may be 012345 or $67^{89}_{23}89$.*

(c) Loss of drive to fourth state (display sequence may be 012345).

5. Eight stable states per cycle or any failure where two successive numbers are skipped.

(a) Second or third stage failure.

6. Ten stable states per cycle, but the lighting sequence is incorrect.

(a) When the wrong neon lamp lights, the trouble is usually a defect in the lamp that should have lit, but it may be a defect in the lamp that lit improperly. It's also possible that more than one lamp will light in place of the correct one.

7. Twelve stable states per cycle.

(a) When lighting sequence is $0123^{01}_{45}456789$* the cause may be a failure of the first feedback or lowered cathode emission in first or second binary.

(b) When the lighting sequence is $01234567^{23}_{89}89$ the cause may be failure of the second feedback or low cathode emission in third or fourth binary.

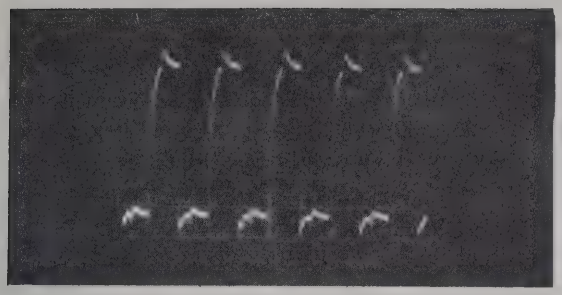
4.3 TABLE OF TYPICAL VOLTAGES AND RESISTANCES

Tube Tube	Pin No.	D-C Voltage with Respect to B-**	Resistance to B- Terminal***
V101	1	170	85K
	2	17	80K
	3, 8	37	8.2K
	4, 5, 9	Filaments	
	6	72	85K
	7	37	80K
V102	1	135	93K
	2	15	83K
	3, 8	30	12K
	4, 5, 9	Filaments	
	6	55	93K
	7	30	83K
V103	1	135	100K
	2	15	83K
	3, 8	30	12K
	4, 5, 9	Filaments	
	6	55	100K
	7	30	83K
V104	1	135	93K
	2	15	83K
	3, 8	30	12K
	4, 5, 9	Filaments	
	6	55	93K
	7	30	83K

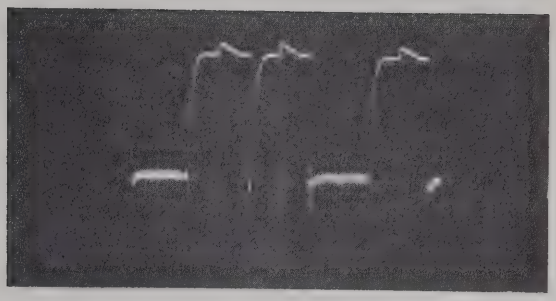
*One digit above another means both lamps are lit.

**Voltages measured in unit with 300-volt plate supply.

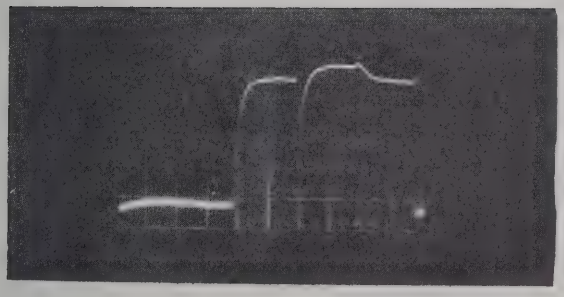
***Before making resistance measurements jumper pins 3 and 8 on the DCU plug.



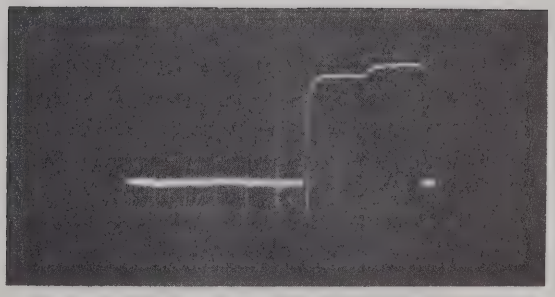
(1) Output of 1st binary at counting rate of 20Kcs. (20v/ cm, 5μsec/ cm)



(2) Output of 2nd binary at counting rate of 20Kcs. (20v/ cm, 5μsec/ cm)



(3) Output of 3rd binary at counting rate of 20Kcs. (20v/ cm, 5μsec/ cm)



(4) Output of 4th binary at counting rate of 20Kcs. (20v/ cm, 5μsec/ cm)

Figure 4. Typical Waveforms. Each picture shows one full cycle of ten counts, beginning at reset. Each registered count score persists one centimeter.

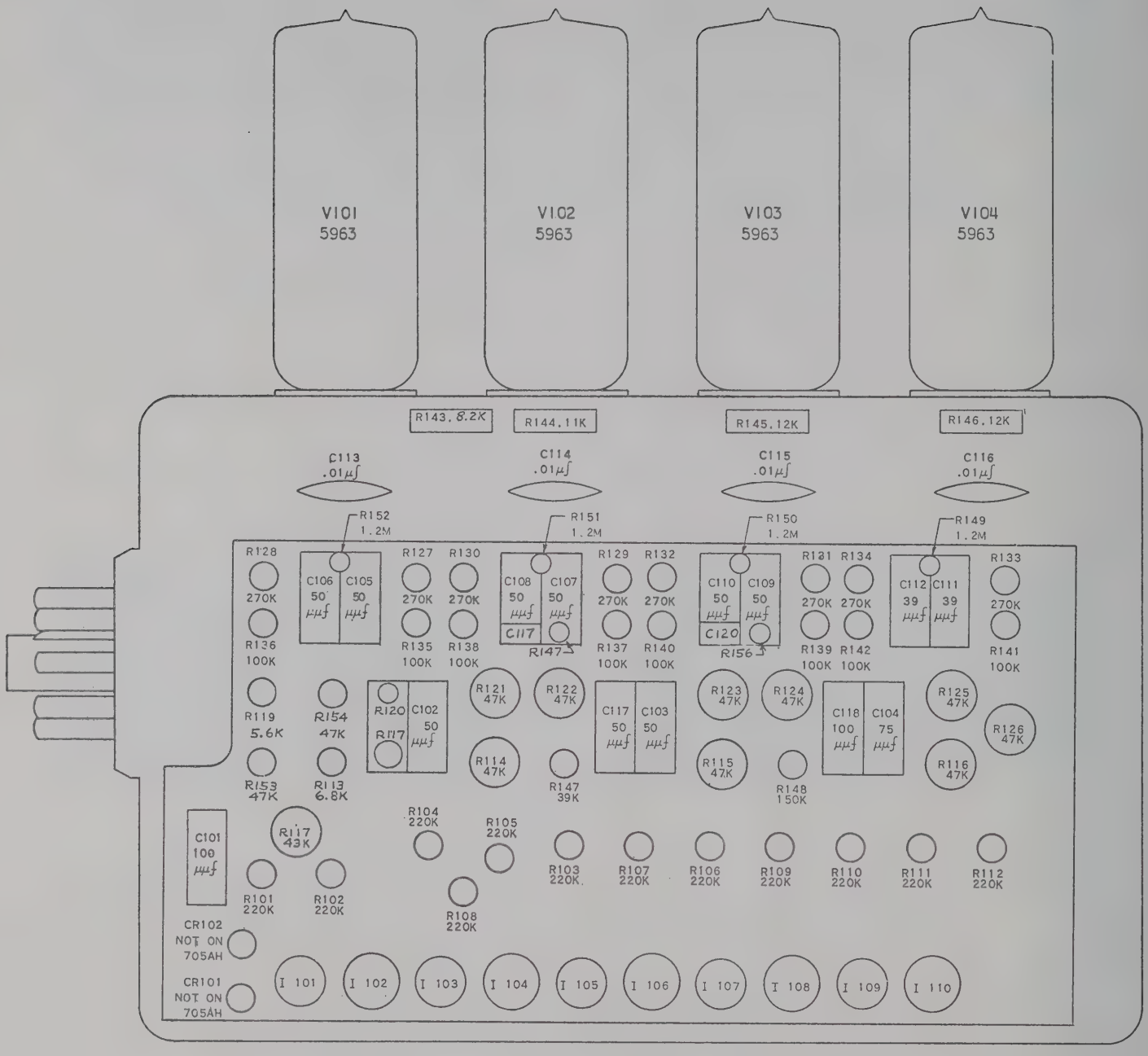
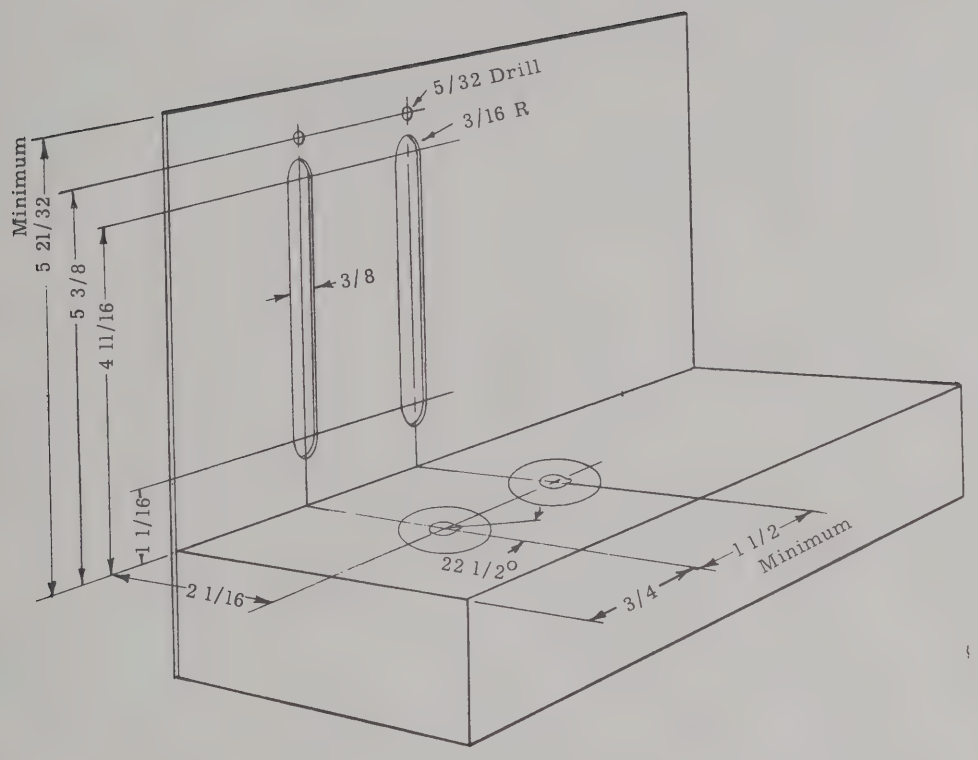
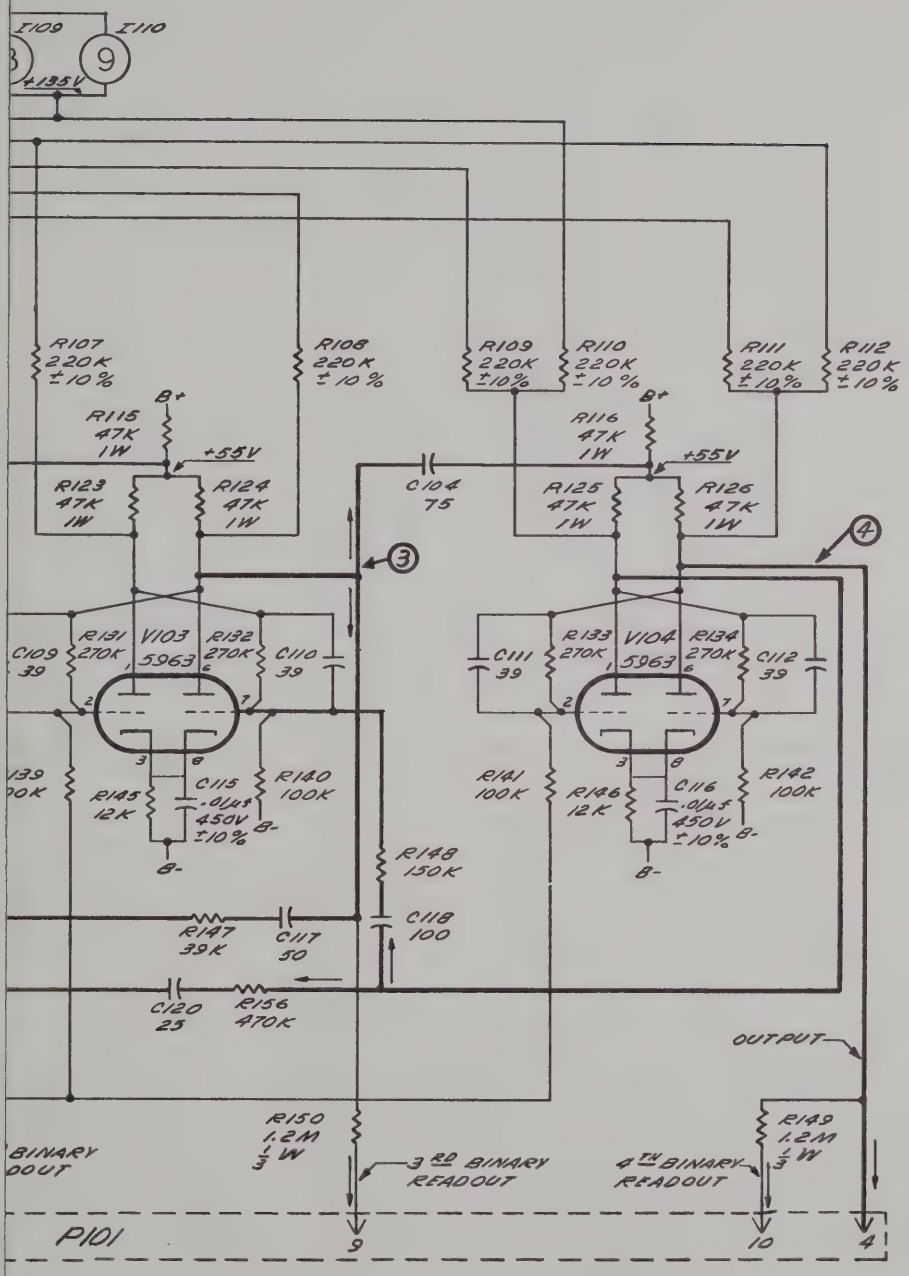


Figure 5. Parts Location



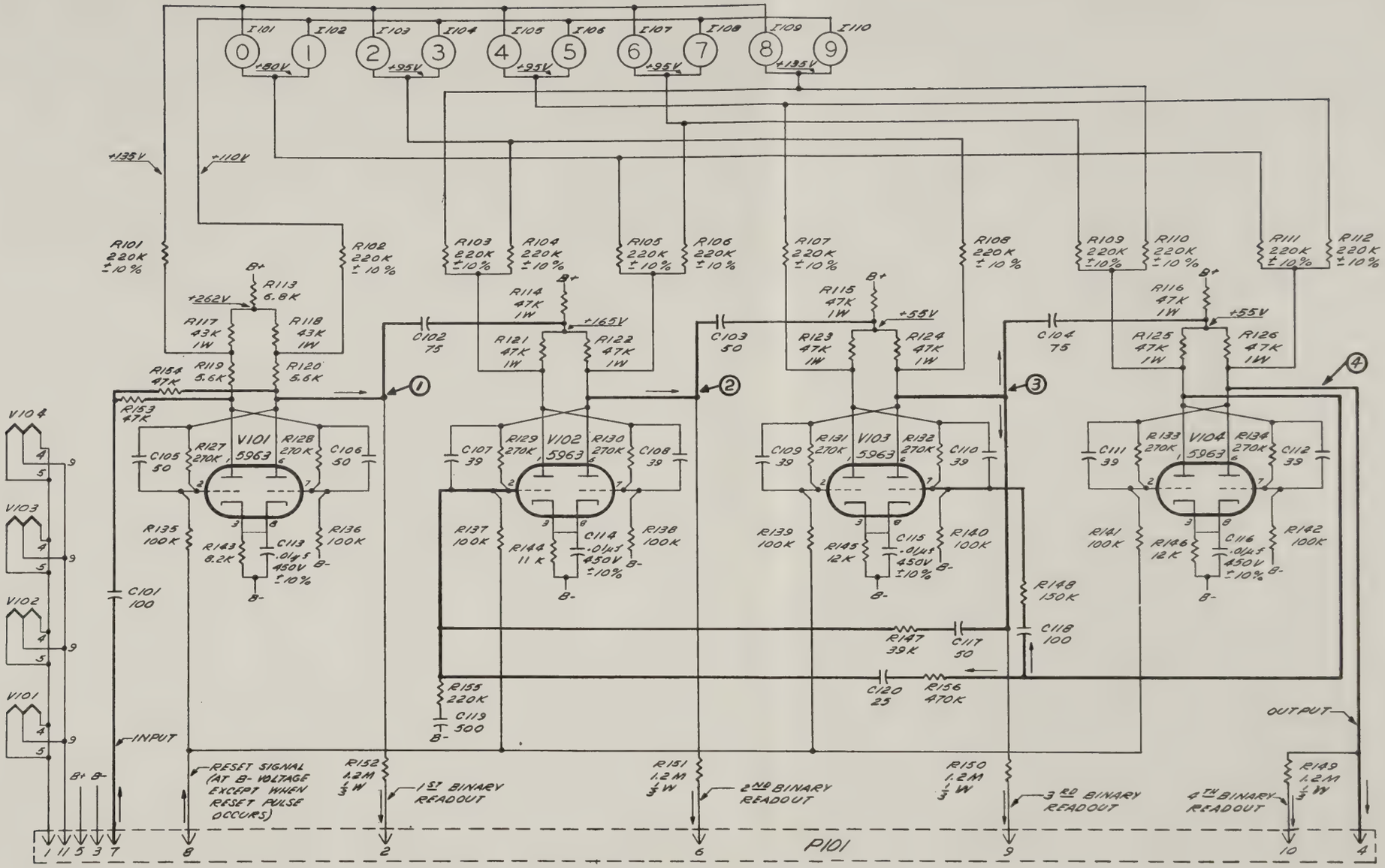
NOTE: Dimensions are based on the use of an Amphenol "MIP" 8 or 11-pin socket mounted above the chassis.

Figure 6. This drawing shows chassis dimensions for mounting two Model 705B DCU's side by side. All modifications of the Model 705B have precisely the same dimensions as the standard 705B.



Lot 1
2-4-58

SCHEMATIC DIAGRAM
MODEL 705B
DECIMAL COUNTING UNIT



NOTES:

1) RESISTORS:
   WATTAGE IS ½ WATT, UNLESS OTHERWISE NOTED.
   TOLERANCE IS 5%, UNLESS OTHERWISE NOTED.
2) CAPACITORS:
   CAPACITY IN µµf UNLESS OTHERWISE NOTED.
   VOLTAGE RATING 500V UNLESS OTHERWISE NOTED.
   TOLERANCE IS 15% UNLESS OTHERWISE NOTED.
3) ALL VOLTAGES MEASURED WITH VTVM UNDER FOLLOWING CONDITIONS:
   a. PLATE SUPPLY OF 300V.
   b. UNIT AT REGISTERED COUNT OF ZERO.
   c. MEASURED WITH RESPECT TO B- USING A VTVM.
4) EXTRA HEAVY LINES DENOTE SIGNAL PATH. SMALL ARROWS (⟶) SHOW DIRECTION OF SIGNAL FLOW.

Lot 1
2-4-58

SCHEMATIC DIAGRAM
MODEL 705B
DECIMAL COUNTING UNIT

INSTRUCTION MANUAL

Models 705AH, 705AJ & 705AK
DECIMAL COUNTING UNITS

Lot No.

BERKELEY division
Beckman Instruments, Inc.

Richmond 4, California
18 March 1957

WARRANTY

Instruments sold by Berkeley Division, Beckman Instruments, Inc., (hereafter called "the Company") are warranted only as stated below.

Subject to the exceptions and upon the conditions specified below, the Company agrees to correct, either by repair, or, at its election, by replacement, any defect of material or workmanship which develops within one year after delivery of the instrument to the original purchaser by the Company or by an authorized representative, provided that investigation and factory inspection by the Company discloses that such defect developed under normal and proper use.

The exceptions and conditions mentioned above are the following:

(a) Some components and accessories by their nature are not intended to, and will not, function one year. If any such component or accessory manufactured by the Company and part of the item sold fails to give reasonable service for a reasonable period of time, the Company will, at its election, replace or repair such component or accessory. What constitutes reasonable service and what constitutes a reasonable period of time shall be determined solely by the Company after the Company is in posession of all the facts concerning operating conditions and other pertinent factors and after such component or accessory has been returned to the Company, transportation prepaid.

(b) All instruments claimed defective must be returned to the Company, transportation charges prepaid, and will be returned to the customer with the transportation charges collect, unless the item is found to be defective in which case the Company will pay all transportation charges.

(c) The Company makes no warranty concerning components or accessories not manufactured by it, such as tubes, fuses, batteries, etc. However, in the event of the failure of any component or accessory not manufactured by the Company, the Company will give reasonable assistance to the purchaser in obtaining from the respective manufacturer whatever adjustment is reasonable in the light of the manufacturer's own warranty.

(d) Except as stated above, the Company makes no warranty, express or implied (either in fact or by operation of law), statutory or otherwise; and, except to the extent stated above, the Company shall have no liability under any warranty, express or implied (either in fact or by operation of law), statutory or otherwise.

(e) The Company expressly disclaims any liability to its customers, dealers, and to users of its products, and to any other person or persons for consequential damages of any kind and from any cause whatsoever arising out of or in any way connected with the manufacture, sale, repair, replacement of, or arising out of or in any way connected with the use of any of its products.

(f) Representations and warranties made by any person, including representatives of the Company, which are inconsistent or in conflict with the terms of this warranty (including but not limited to the limitation of the liability of the Company as set forth above) shall not be binding upon the Company unless reduced to writing and approved by an officer of the Company.

(g) This warranty shall be governed by the laws of the State of California.

Claims for damage in shipment should be filed promptly with the transportation company.

All correspondence concerning the instrument should specify the model and serial number. This information appears on the company name plate. Any inquiry concerning details of operation, possible modifications, etc., should be addressed to the Sales Department, Berkeley division of Beckman Instruments, Inc., Richmond 4, California.

REPAIR SERVICE

Experienced service personnel and special test equipment are available at the factory to perform any necessary repairs. Every effort will be made to expedite the repair of instruments returned for servicing. Repair work will be performed only upon receipt of a written purchase order or authorization. Instruments to be repaired should be addressed to SERVICE AND REPAIR DEPARTMENT with transportation charges prepaid. Repaired instruments will be returned to the purchaser with transportation charges collect.

Berkeley reserves the right to make changes in design at any time without incurring any obligation to modify equipment previously purchased to conform to subsequent design changes.

BERKELEY DIVISION
BECKMAN INSTRUMENTS, INC.

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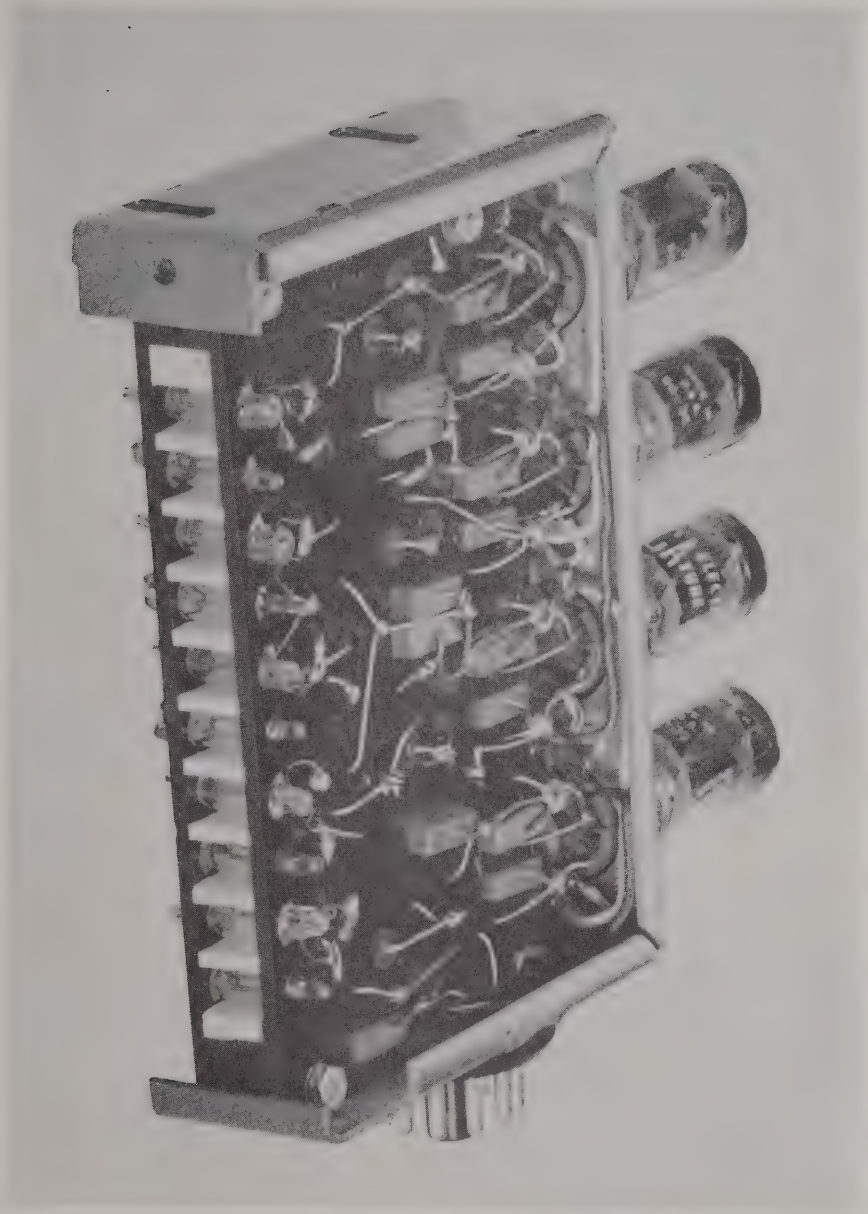
INSTRUCTION MANUAL REVISION

Models affected:

605	730A	7151
705A	903	7161
705AH	2020	7351
705AJ	2200	7361
705B	4904	7410
706A	5001	7420

Delete all references to tube type 7316



Model 705AH Decimal Counting Unit with side covers and indicating panel removed.

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INTRODUCTION

These decimal counting units are direct-reading, plug-in electronic counters. The number of input pulses received is indicated by the illumination of one of ten neon lamps placed behind a numbered acetate panel. Each unit counts from zero to nine, the tenth pulse resetting the counter to zero and simultaneously generating an output signal. Any number of these units can be connected in cascade (the output of one unit driving the next) forming a counter whose total count capacity depends only on the number of DCU's. Thus, five units will count to 99, 999 resetting to "00, 000" on the 100, 000th pulse.

Models 705AH and 705AK generate a binary coded decimal readout. This code is in the form of high or low voltages at each of four pins on the DCU plug.

SPECIFICATIONS

Count Indication

Direct reading, decimal presentation

Power Requirements

Heaters: 6.3 v. at 1.2 amps

Plates: 300 v. at 13 ma

Input Requirements

Negative pulses (See "OPERATION")

Output Characteristics

Designed to drive a Model 705A DCU or any modification thereof (i.e., 705AH, 705AK, etc.)

Resolution of Paired Pulses

5 microseconds

Reset

Will reset to either zero or nine depending on polarity of reset pulse applied.

Maximum Counting Rate

100, 000 counts per second

Construction

Plug-in unit, 11-pin socket

OPERATION

Power Requirements. The heaters require 6.3 volts ac at 1.2 amperes. The plate circuits may be operated on from 200 to 400 volts, although the design center is 300 volts at 13 ma. Plate voltage may be applied in the form of B + and B - voltages. The d-c level of all output voltages will depend upon the level of the plate supply voltages.

Input Requirements. A negative pulse at least two microseconds wide is required to drive the unit. The optimum pulse amplitude depends on the rise time. With a rise time of 0.5 microseconds (measured between ten and ninety percent values) the pulse amplitude should be between 75 and 135 volts. With a two-microsecond rise time, the amplitude should be between 120 and 165 volts. When operating the plate circuits on 300 volts, optimum performance is obtained with a rise time of one microsecond or less and a pulse amplitude of 100 volts. If the unit is powered by unregulated d-c supplies, the input pulse amplitude should vary in phase with the supply voltage. The input load presented when an input pulse occurs is 15K ohms in series with 100 micromicrofarads.

Output Characteristics. The output is the rectangular waveform shown in Figure 3. As every tenth input pulse triggers the unit from count display "9" to count display "0", a negative transient occurs at pin 4 of the DCU plug. With a plate supply of 300 volts, the potential at pin 4 drops from + 135 to + 55 volts with respect to B-. This transient can be used to drive succeeding decimal counting units or other circuitry. The load impedance connected

between the output terminal and ground must not be less than 300K or 6K in series with 100 micro-microfarads.

Method of Resetting after a Counting Period. A DCU can be reset to a registered count of either zero or nine by the application of a voltage pulse of the proper polarity to the proper pin of the DCU plug. See the table below.

	RESET TO ZERO		RESET TO NINE	
	Pulse Polarity	Applied at Pin No.	Pulse Polarity	Applied at Pin No.
705AH	Neg.	8	Pos.	8
705AJ	Neg.	8	Pos.	8
	Pos.	3	Neg.	3
705AK	Neg.	8	Pos.	8

The reset pin (or pins in the base of Model 705AJ) should be maintained at the B- supply voltage except when a reset pulse occurs. A 50-volt pulse at least 3μseconds wide is adequate. A 100-volt pulse need be only 1.5μseconds wide. There is no maximum pulse width; however the DCU will not begin counting again until the reset pin returns to the B- supply voltage.

Simply disconnecting a reset pin from B- with a switch or relay will have the same effect as applying a positive pulse.

Binary Code Readout. Models 705AH and 705AK generate a modified binary code representing the decimal digit registered. The code appears in the form of a voltage (high or low) at one plate of each of four double-triode binaries. In the table below, "0" represents a plate voltage of approximately +55 volts with respect to B-; "1" represents a plate voltage of about +135 volts with respect to B-. (These are the voltage levels which appear when using a 300-volt plate supply.) Each of the four plates is coupled to a pin of the DCU plug through a 1.2 megohm resistor except in the case of pin 4 on the 705AK DCU. This pin is connected directly to a plate of the fourth binary. To obtain a readout voltage at this pin, it is necessary to add a 1.2M resistor externally.

DECIMAL DIGIT REGISTERED	FOUR - LINE BINARY CODE			
	1st Binary Stage (Pin 2 of DCU plug)	2nd Binary Stage (pin 6 of DCU plug)	3rd Binary Stage (Pin 9 of DCU plug)	4th Binary (Pin 10, 705AH) (Pin 4, 705AK)
0	0	0	0	0
1	1	0	0	0
2	0	1	0	0
3	1	1	0	0
4	0	1	1	0
5	1	1	1	0
6	0	0	1	1
7	1	0	1	1
8	0	1	1	1
9	1	1	1	1

Extinguishing the Indicating Lamps During the Counting Period. On Models 705AJ and 705AK, it is possible to prevent the neon bulbs from lighting by placing approximately -100 volts with respect to B- on pin 10 of the DCU plug. Ordinarily, the user will wish to extinguish the bulb while the DCU is actively counting, and to allow them to light, indicating the registered count at the end of a counting period.

CIRCUIT DESCRIPTION

The Binaries. The decimal counting units contain four "flip-flop" circuits. These circuits are slightly modified versions of the Eccles-Jordan trigger circuit. They are referred to here as binaries.

Figure 1 is a schematic diagram of a typical binary. It consists of two triode voltage amplifiers with the plate of each direct-coupled to the grid of the other. With no input this circuit assumes one of two stable states: V1 conducting steadily and V2 cut

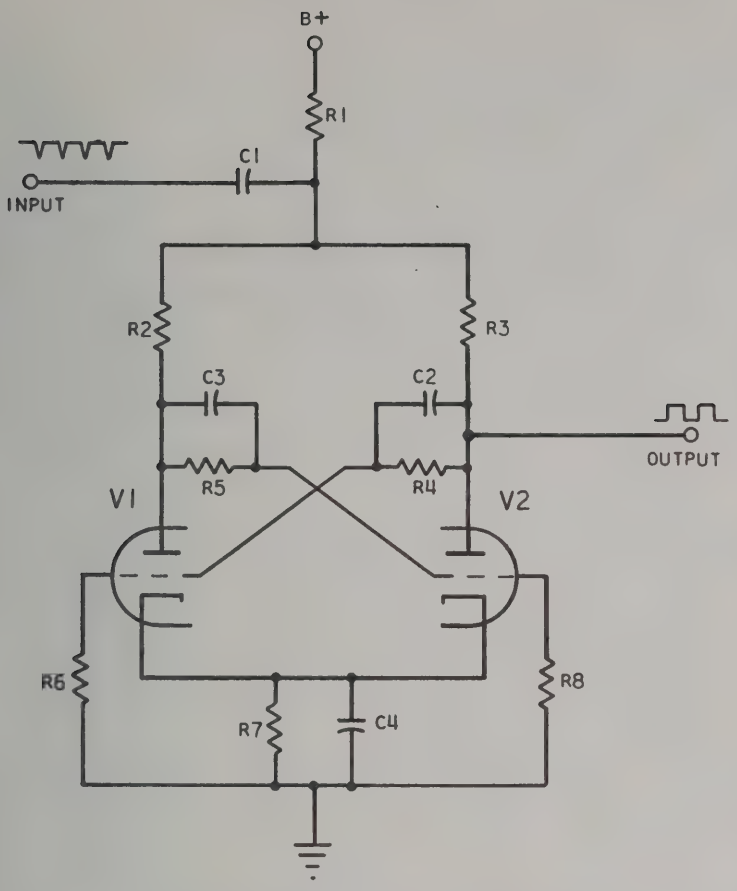


FIGURE 1. A TYPICAL BINARY.

off, or V2 conducting and V1 cut off. Suppose V1 is not conducting. Then, its plate is near the B- voltage. A portion of this voltage, applied to the grid of V2 through the voltage dividing network R5 and R8, raises this grid above cut-off and permits V2 to conduct. While V2 is conducting, the low positive potential at its plate, coupled to the grid of V1 through the dividing network R4 and R6, holds this grid several volts below cut-off. Since small changes in the potential at the grid of V1 will not raise it above cut-off, this state is stable and will persist until disturbed by an appreciable input signal. Notice that, since the circuit is symmetrical, the opposite state is equally stable.

The circuit is triggered from one state to another by negative pulses applied at the input. For example, assume that V2 is conducting and V1 is cut off. If a negative pulse is applied to the input, there is a drop in the plate voltage of V1. This drop in voltage is transmitted through a crossover network (R5, R8, C3 and the grid-to-ground capacitance of V2) and applied to the grid of V2. The plate voltage of V2 then starts to rise, carrying with it the grid of V1. If the input pulse is of sufficient amplitude, V1 begins to conduct. The moment V1 conducts, the drop in voltage at its plate, coupled to the grid of V1, reinforces the negative transient there. This regenerative action proceeds rapidly until V2 is cut off and V1 is conducting at a steady rate. The next adequate input transient causes a reverse action and returns the binary to its original state. Thus, the binary completes a cycle for every two input transients applied, making it a scale-of-two. The output is the drop in voltage at one of the plates as that triode begins to conduct. This output, consisting of one negative transient for every two input transients, is suitable for driving another binary. By connecting binaries in cascade (output of one to input of the next) a counter having a scale of any power of two can be built.

The Scale of Ten. In the Model 705A four binaries are connected in cascade forming a scale-of-16 which is permuted to a scale-of-10 by two positive feedback paths. (See Figures 2 and 3). For the first three negative input pulses, the unit operates like a simple binary counter. At the fourth input pulse, the third binary is triggered for the first time, sending a pulse through the first feedback path which triggers the second binary. Since it requires two input pulses to trigger the second binary, this is equivalent to adding two input pulses; therefore, the state of the unit now

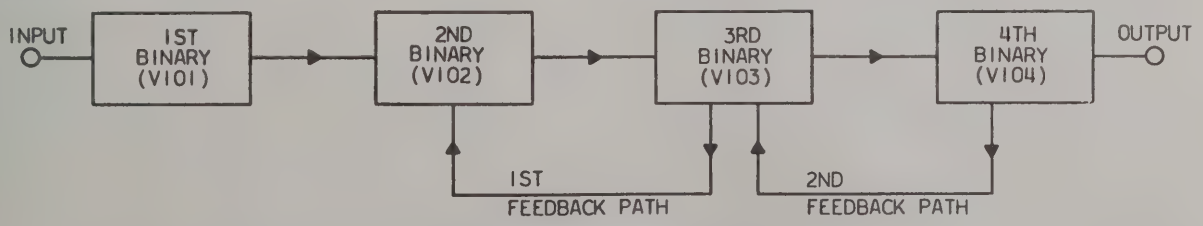


FIGURE 2. BLOCK DIAGRAM.

corresponds to a binary count of six. The sixth input pulse (equivalent to the eight in a simple binary chain) triggers the fourth binary which sends a pulse through the second feedback path, triggering the third binary. This is equivalent to adding four more input pulses so the state of the unit now corresponds to a binary count of 12. For the next four input pulses (7 thru 10) the unit operates again as a simple binary chain, producing an output pulse at the tenth input pulse. Adding the equivalent of six input pulses internally has changed the binary chain from a scale-of-16 to a scale-of-10.

When the third binary is triggered by a feedback pulse, it tends to retrigger the second binary in the same way that it did at the time of input pulse four. This tendency is offset by a simultaneous opposing signal from the fourth binary.

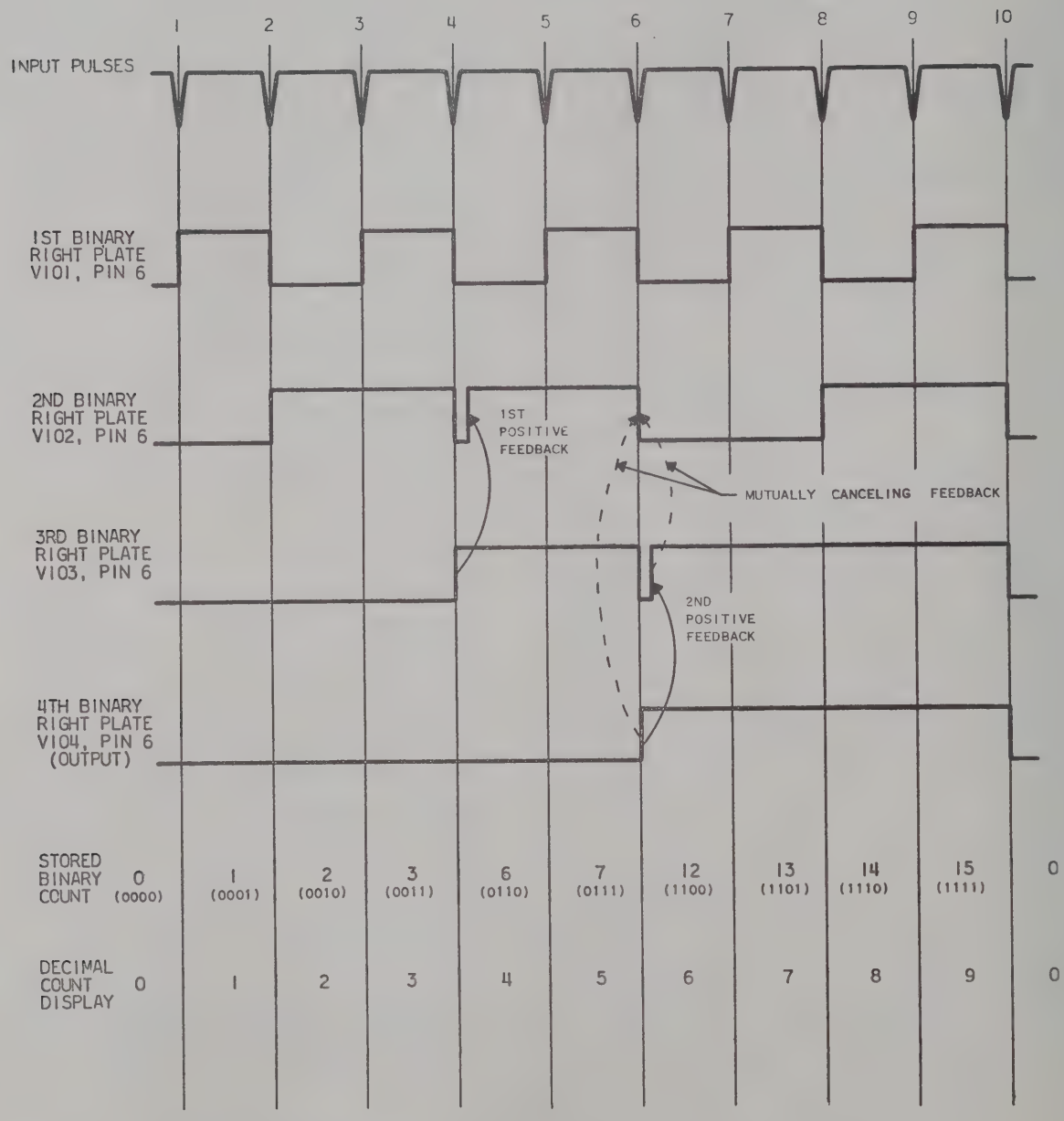


FIGURE 3. IDEALIZED WAVEFORMS. "RIGHT PLATE" REFERS TO THE PLATE APPEARING ON THE RIGHT-HAND SIDE OF THE BINARY AS DRAWN ON THE SCHEMATIC.

TROUBLESHOOTING PROCEDURES

When a decimal counting unit is suspected of counting incorrectly, it should be interchanged with another unit in the instrument or replaced with a spare unit to determine whether the trouble is in the suspected unit or in the associated circuitry. This test should be made very carefully. Because the counting unit is usually the indicating device of an instrument, it is often accused of operating incorrectly when the fault is external to it.

Two methods are recommended for locating a defect in a DCU. The first is to observe the lighting sequence while driving the unit at a slow pulse rate. The second is to study the output waveform of each binary while driving the unit fast enough to create an oscilloscope display. It is impossible to say which method should be used in every case, since marginal failures may occur at high counting speeds and not at lower counting rates, and vice versa. The first method is the only way that a neon lamp failure can be located, and it can be used to locate component and tube failures. For this reason, it is recommended that this method be used first. The table of common troubles lists the probable defects indicated by particular variations from the proper lighting sequence. Binary output waveforms may be compared with the idealized waveforms of Figure 3 and the photographs appearing in Figure 4 & 5.

A table of typical voltages and resistances has been provided to help the serviceman locate a defect within one of the binary stages. Values may deviate considerably from those given without causing trouble. The fact that the unit is designed to operate at plate supply voltages ranging from 200 to 400 volts is a rough indication of permissable tolerances.

TROUBLESHOOTING CHART

NOTE: Reset unit to zero before testing for symptoms

SYMPTOMS	POSSIBLE CAUSES
Unit Fails to Count	(a) Insufficient supply voltage. (b) Input signal of insufficient amplitude (c) Input signal of wrong polarity. (d) First stage inoperative.
Unit Counts Spuriously	(a) Extraneous input signals. (b) Pulses received through power supply. (c) External voltages picked up by output lead.
Units Counts Erratically	(a) Input signal too large or small, incorrect rise time. (b) Supply voltage fluctuating too much.
Unit Fails to Reset	(a) Stray counts from reset switch or associated circuitry. (b) Defective component.

Units counts regularly but neon bulbs light in wrong sequence and the pattern of lighting is repeated consistently after a definite number of input pulses. One or more bulbs may be lit simultaneously during a cycle but the number of states per cycle remains constant.

1. Units skips every other number	(a) First stage defective. (b) Input circuit supplies double pulses.
2. Two stable states per cycle.	(a) Second stage defective (Display sequence may be 01 or 45). (b) Loss of drive to second stage (01).
3. Four stable states per cycle.	(a) Third stage defective (Display sequence may be 0123 or 6789). (b) Loss of drive to third stage (0123).
4. Six stable states per cycle.	(a) Output excessively loaded (Display sequence may be 012345). (b) Last stage inoperative (Display sequence may be 012345 or $67\overset{89}{\underset{23}{}}89$* (c) Loss of drive to fourth stage (Display sequence may be 012345).
5. Eight stable states per cycle or any failure where two successive numbers are skipped.	(a) Second or third stage failure.
6. Ten stable states per cycle, but the lighting sequence is incorrect.	(a) When the wrong neon lamp lights, the trouble is usually a defect in the lamp that should have lit, but it may be a defect in the lamp that lit improperly. It's also possible that more than one lamp will light in place of the correct one.
7. Twelve stable states per cycle.	(a) When lighting sequence is $0123\overset{01}{\underset{45}{}}456789$* the cause may be a failure of the first feedback or lowered cathode emission in first or second binary. (b) When the lighting sequence is $01234567\overset{23}{\underset{89}{}}89$ the cause may be failure of the second feedback or low cathode emission in third or fourth binary.

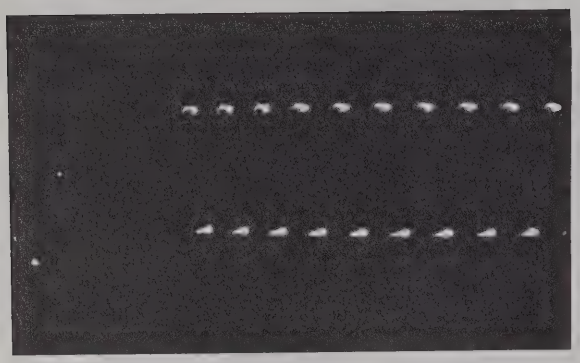
* One digit above another means both lamps are lit.

TABLE OF VOLTAGES & RESISTANCES

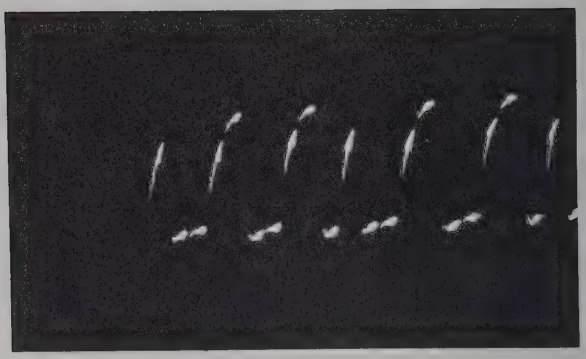
Tube	Pin No.	D-C. Voltage with respect to B-.*	Resistance to B minus Terminal**
V101	1	170	105K
	2	17	85K
	3, 8	37	12K
	4, 5, 9	Filaments	
	6	60	105K
	7	37	85K
V102	1	135	93K
	2	15	83K
	3, 8	30	12K
	4, 5, 9	Filaments	
	6	55	93K
	7	30	83K
V103	1	135	100K
	2	15	83K
	3, 8	30	12K
	4, 5, 9	Filaments	
	6	55	100K
	7	30	83K
V104	1	135	93K
	2	15	83K
	3, 8	30	12K
	4, 5, 9	Filaments	
	6	55	93K
	7	30	83K

* Voltages measured in unit with 300-volt plate supply

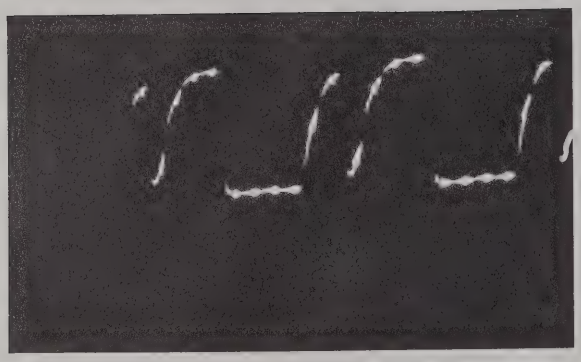
** Before making resistance measurements jumper pins 3 and 8 on the DCU plug.



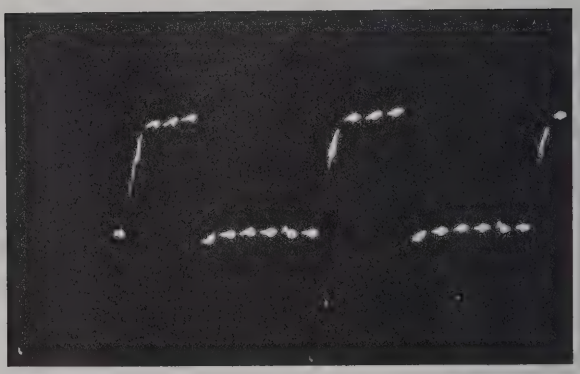
(1) First Binary Output (V101, Pin 6).
Upper voltage level is +168v
Lower voltage level is +55v



(2) Second Binary Output (V102, Pin 6)
Upper voltage level is +140v
Lower voltage level is +55v.

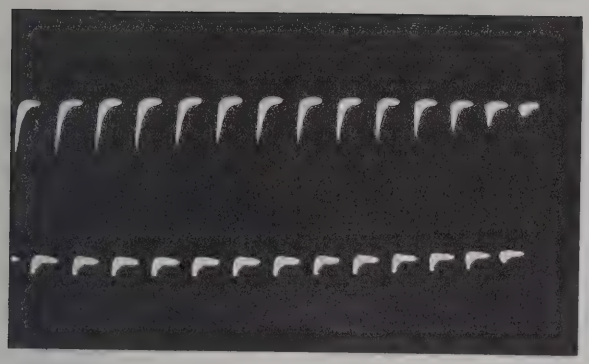


(3) Third Binary Output (V103, Pin 6)
Upper voltage level is +140v.
Lower voltage level is +55v.

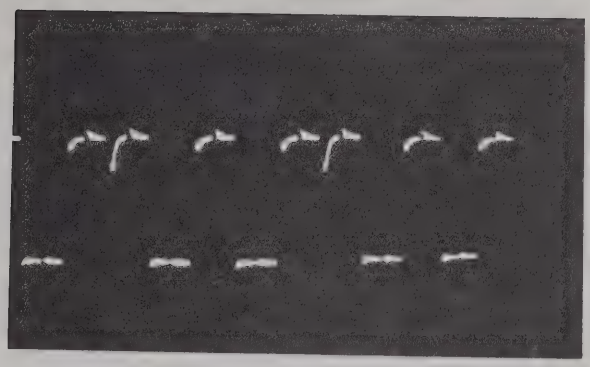


(4) Fourth Binary Output (V104, Pin 6).
Upper voltage level is +140v.
Lower voltage level is +55v.

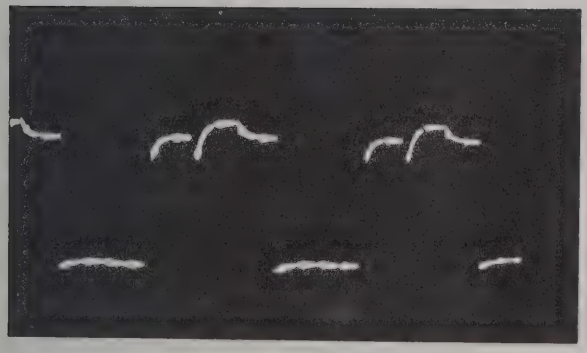
FIGURE 4. BLANKED WAVEFORMS AT INPUT FREQUENCY OF 20KC. ALL VOLTAGE LEVELS ARE MEASURED WITH RESPECT TO B MINUS.



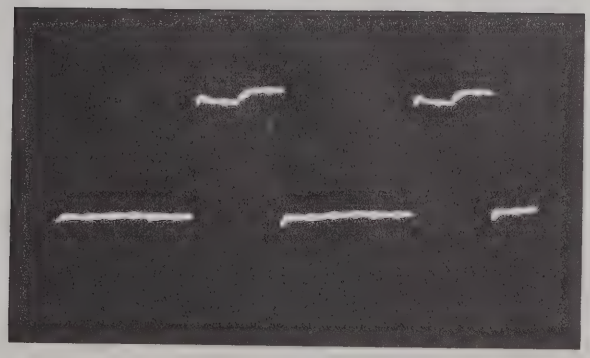
(1) First Binary Output (V101, Pin 6).
Upper Voltage level is +168V
Lower voltage level is +55v



(2) Second Binary Output (V102, Pin 6)
Upper voltage level is +140v
Lower voltage level is +55v.



(3) Third Binary Output (V103, Pin 6)
Upper voltage level is +140v.
Lower voltage level is +55v



(4) Fourth Binary Output (V104, Pin 6).
Upper voltage level is +140v.
Lower voltage level is +55v.

FIGURE 5. BLANKED WAVEFORMS AT INPUT FREQUENCY OF 100KC. ALL VOLTAGE LEVELS ARE MEASURED WITH RESPECT TO B MINUS.

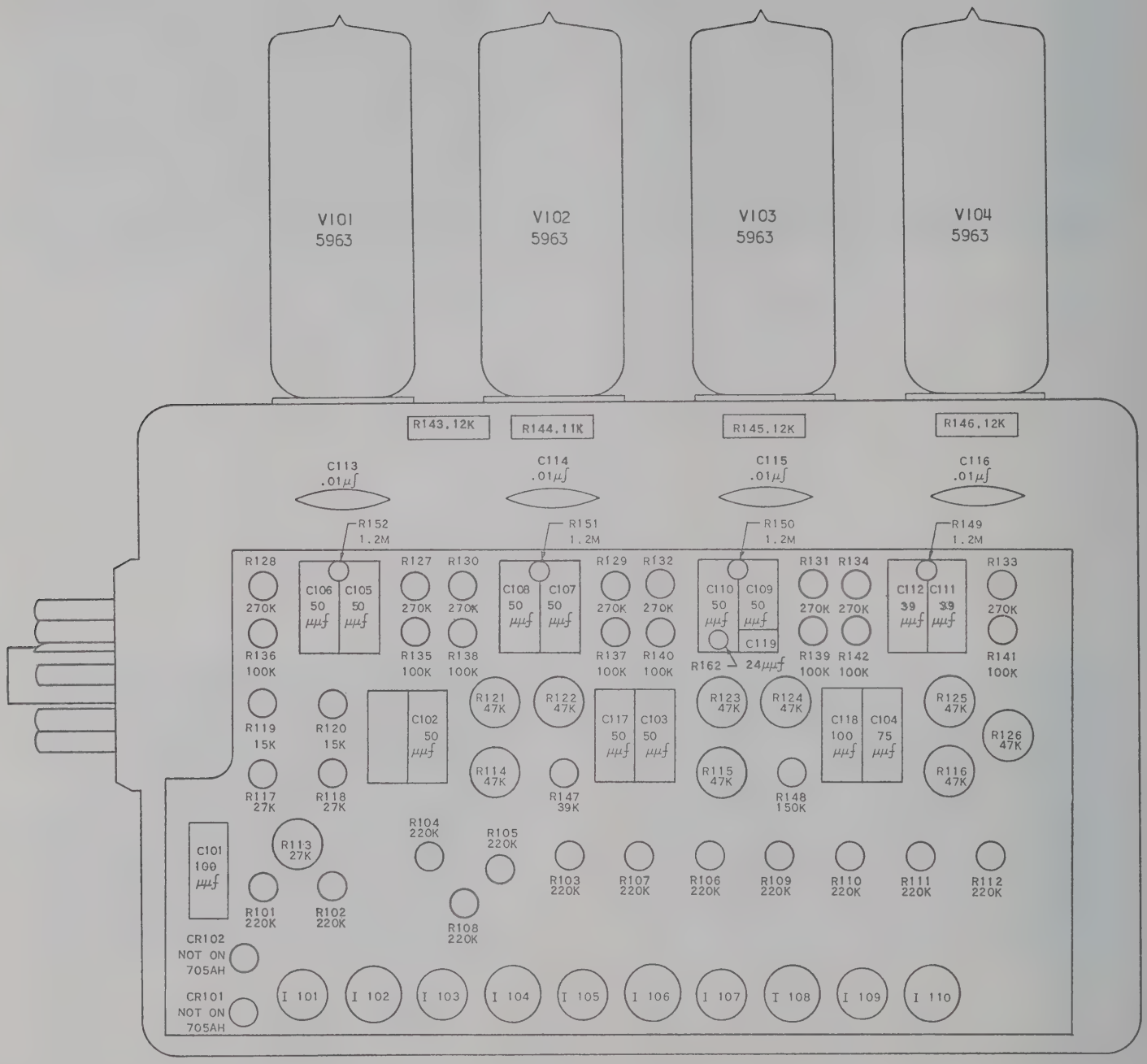
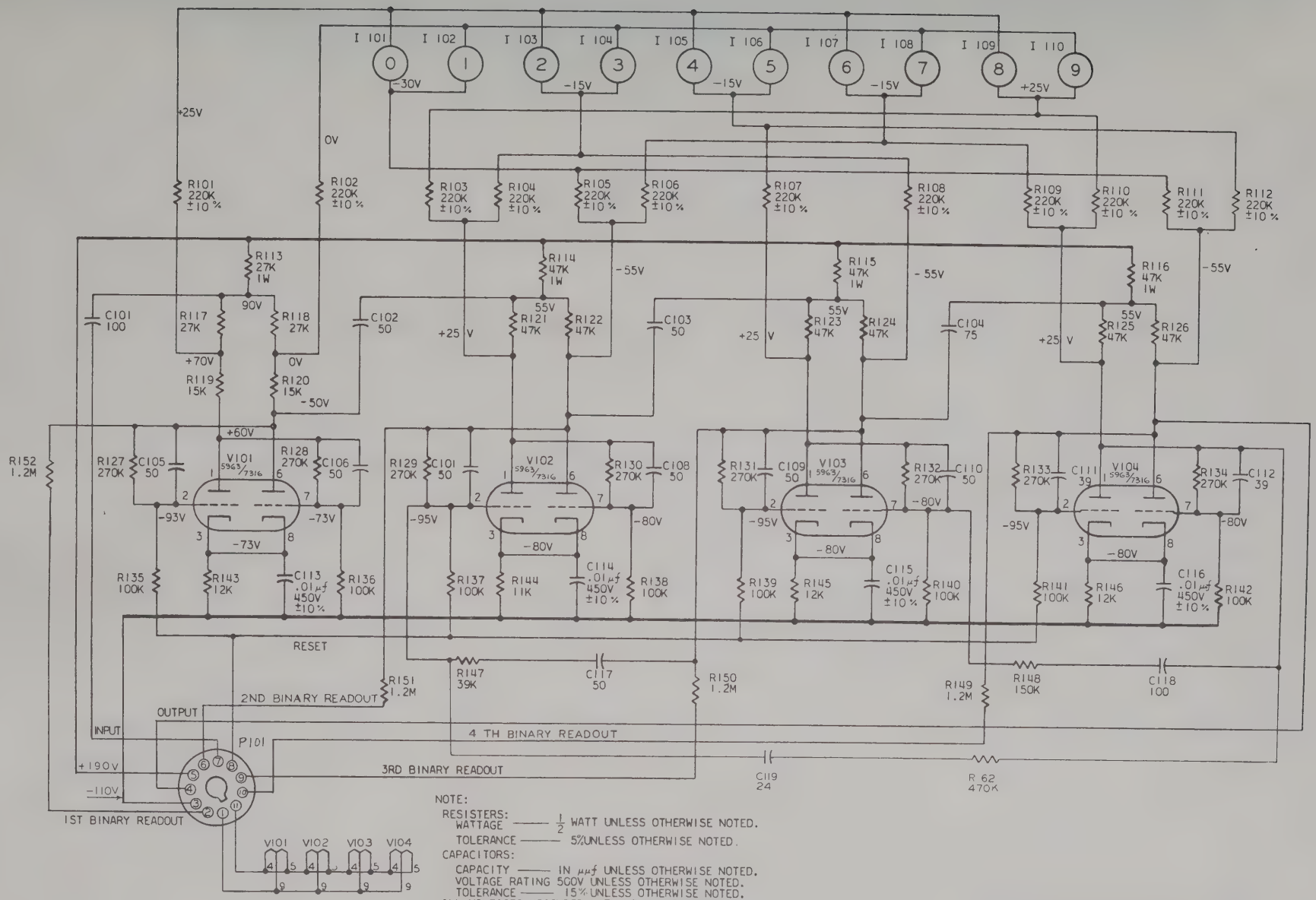
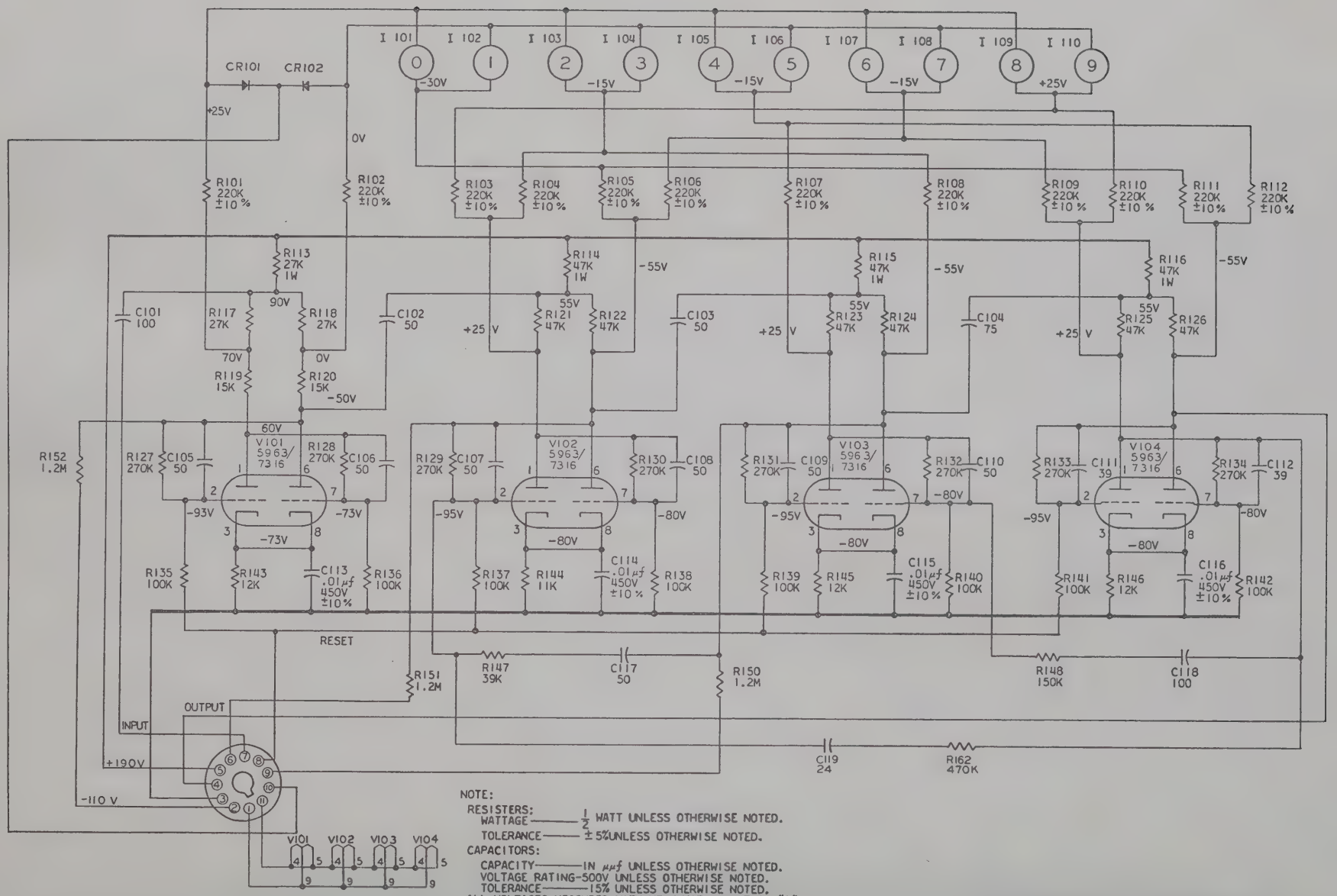


FIGURE 6. PARTS LOCATION



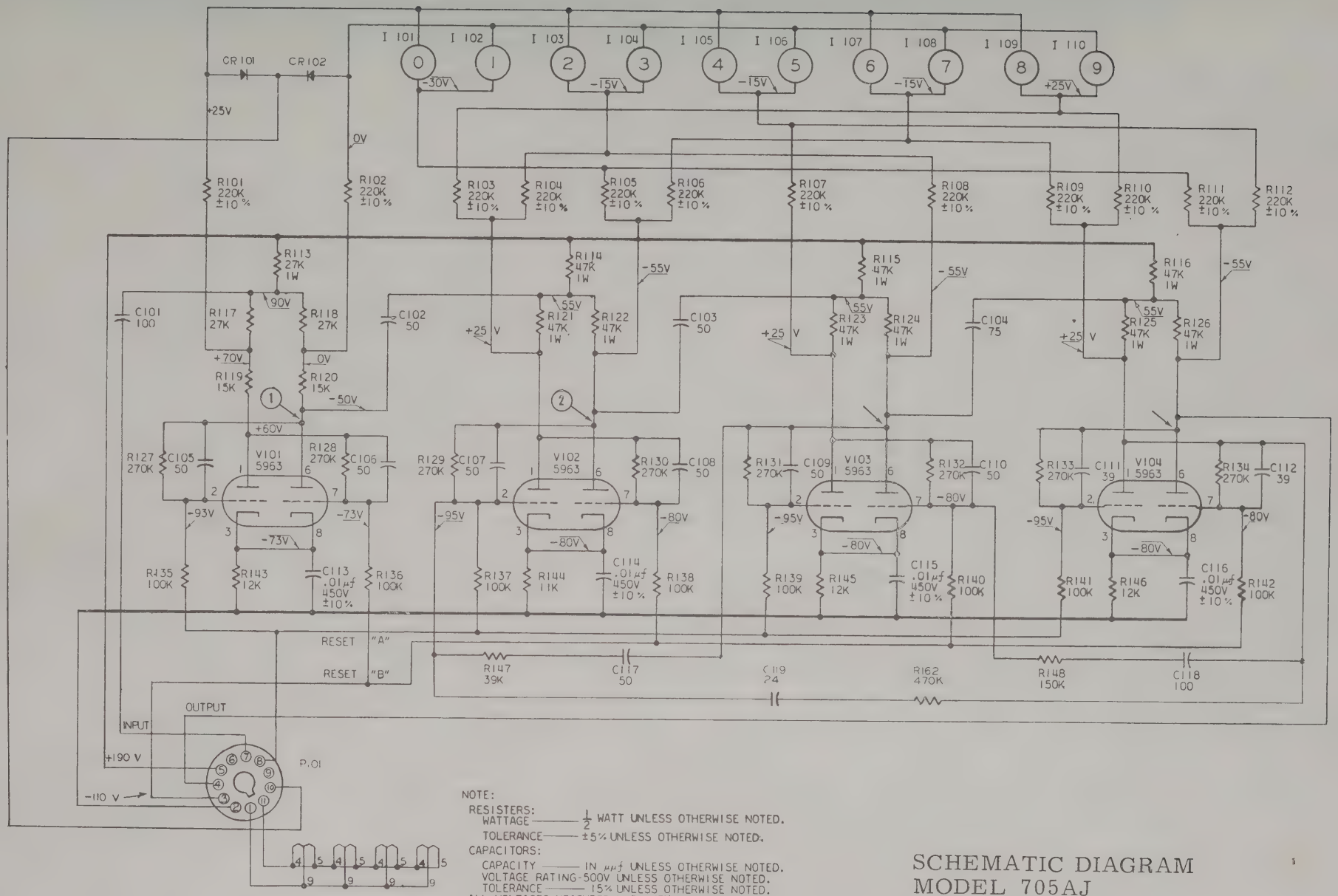
NOTE:
RESISTERS:
WATTAGE —— $\frac{1}{2}$ WATT UNLESS OTHERWISE NOTED.
TOLERANCE —— 5% UNLESS OTHERWISE NOTED.
CAPACITORS:
CAPACITY —— IN $\mu\mu f$ UNLESS OTHERWISE NOTED.
VOLTAGE RATING 500V UNLESS OTHERWISE NOTED.
TOLERANCE —— 15% UNLESS OTHERWISE NOTED.
ALL VOLTAGES MEASURED WITH VTVM WITH COUNT AT "0".

SCHEMATIC DIAGRAM
MODEL 705AH
DECIMAL COUNTING UNIT



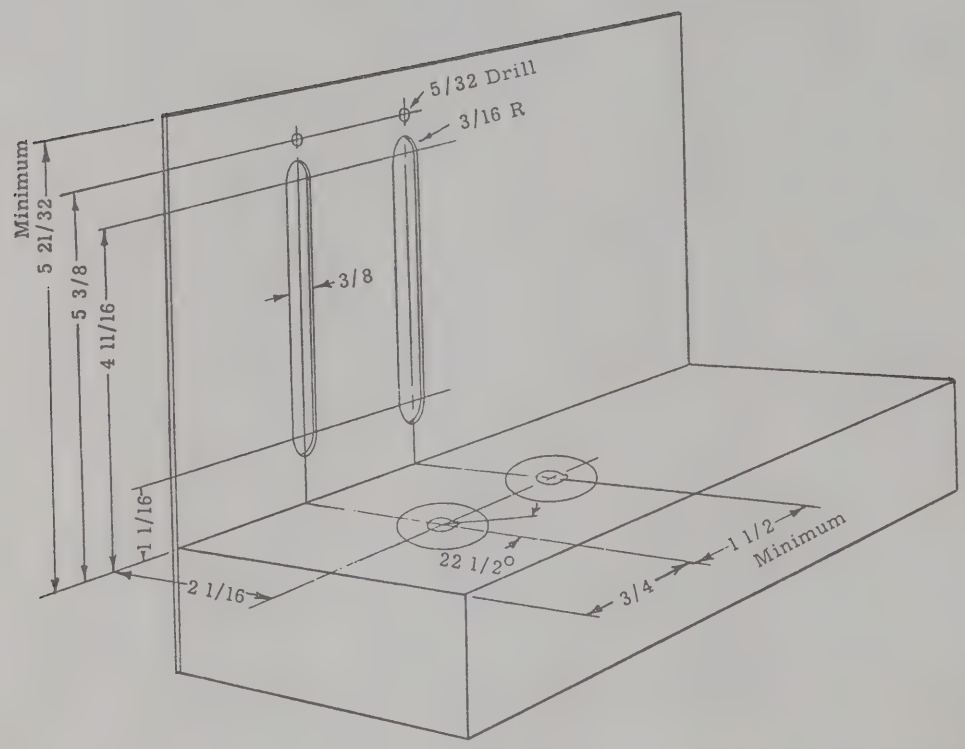
NOTE:
RESISTERS:
WATTAGE——$\frac{1}{2}$ WATT UNLESS OTHERWISE NOTED.
TOLERANCE——±5% UNLESS OTHERWISE NOTED.
CAPACITORS:
CAPACITY——IN μμf UNLESS OTHERWISE NOTED.
VOLTAGE RATING-500V UNLESS OTHERWISE NOTED.
TOLERANCE——15% UNLESS OTHERWISE NOTED.
ALL VOLTAGES MEASURED WITH VTVM WITH COUNT AT "0".

SCHEMATIC DIAGRAM
MODEL 705AK
DECIMAL COUNTING UNIT



NOTE:
RESISTERS:
WATTAGE ——— ½ WATT UNLESS OTHERWISE NOTED.
TOLERANCE ——— ±5% UNLESS OTHERWISE NOTED.
CAPACITORS:
CAPACITY ——— IN μμf UNLESS OTHERWISE NOTED.
VOLTAGE RATING-500V UNLESS OTHERWISE NOTED.
TOLERANCE ——— 15% UNLESS OTHERWISE NOTED.
ALL VOLTAGES MEASURED WITH VTVM WITH COUNT AT "0".
AND PIN #10 DISCONNECTED.

SCHEMATIC DIAGRAM
MODEL 705AJ
DECIMAL COUNTING UNIT



NOTE: Dimensions are based on the use of an Amphenol "MIP" 8 or 11-pin socket mounted above the chassis.

The drawing shows chassis dimensions for mounting two Model 705A DCU's side by side. All modifications of the Model 705A (705AH, 705AF, etc.) have precisely the same dimensions as the standard 705A.

Mounting Dimensions, Model 705A and All Modifications Thereof

INSTRUCTION MANUAL

Model 705AHJ
DECIMAL COUNTING UNIT

Lot No._____

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Schematic Diagram	2

Appendix

Model 705AH, AJ, AK Instruction Manual

Beckman

Berkeley Division
2200 Wright Avenue, Richmond 3, California
a division of Beckman Instruments, Inc.

September 23, 1957

Model 705AHJ Decimal Counting Unit

The decimal counting unit for which this manual is provided is a Model 705AHJ. It is identical to the Model 705AH described in the accompanying manual except for the changes listed below.

1. The output signal occurs at count "1" instead of count "10". This signal is derived from the voltage occuring at the junction of the three added resistors R155, R156, R157.

2. A lamp extinguish circuit has been added which operates from a negative voltage applied at pin 10. This circuit is identical to that described for the Model 705AJ DCU.

3. The wiring at connector plug P101 has been altered to accommodate the changes.

The Model 705AHJ is designed for applications where an output pulse is required at count "1" and the common method of reset to zero on count "10" is employed.

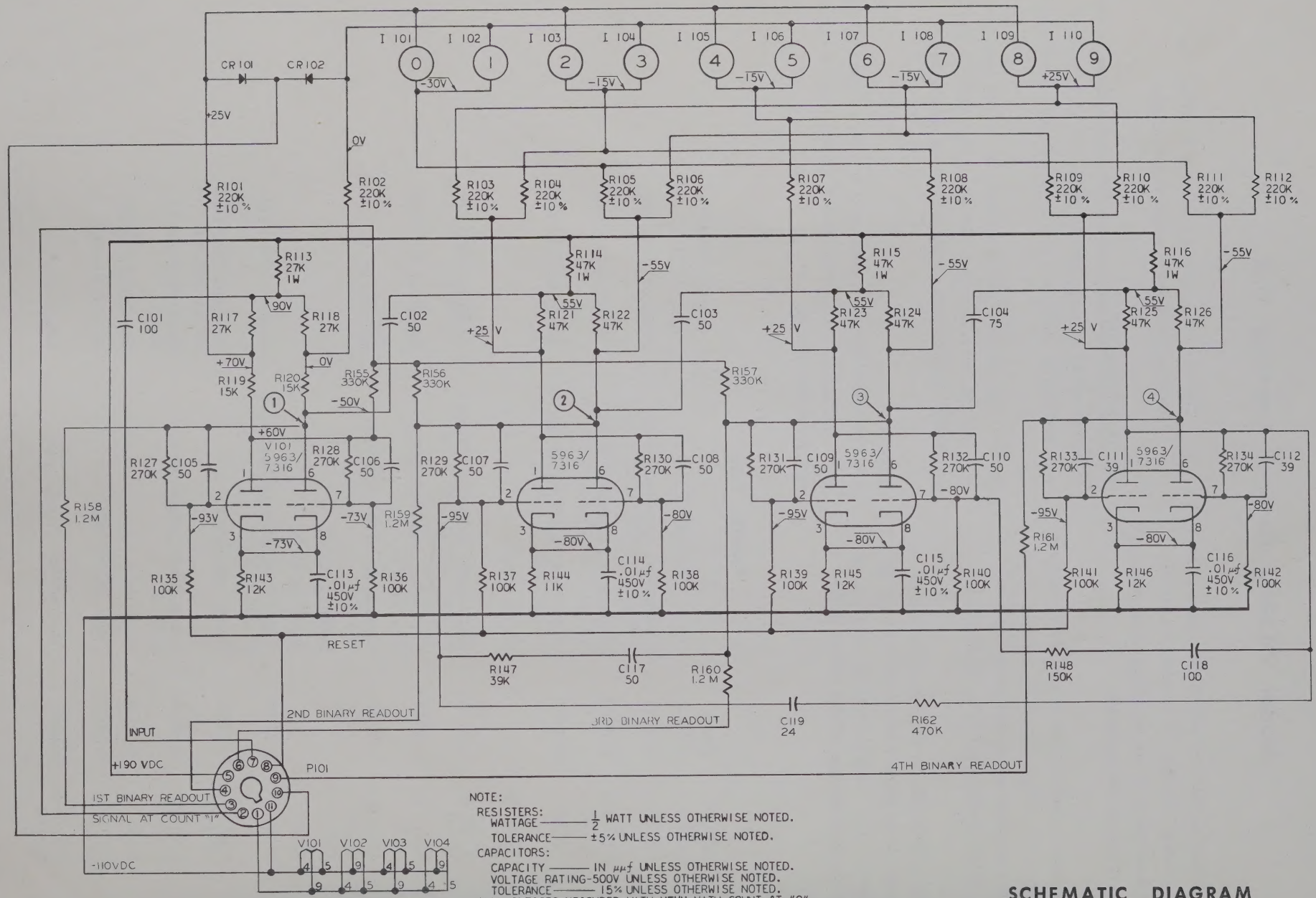
Refer to the Model 705AH, 705AJ, & 705AK instruction manual for a full description of this DCU. The schematic diagram is shown on the following page.

PARTS

All resistors are identified as to value, power, rating and tolerance on the schematic diagram. Other parts are identified below.

PARTS LIST

Detail No.	Stock No.	Description	Manufacturer & No.
C101	2-0501	Capacitor, silvered mica, 100 $\mu\mu$f, 500 V, 5%	Sangamo KR1310
C102 & C103	2-1704	Capacitor, silvered mica, 50 $\mu\mu$f, 500 V, 5%	Sangamo KR1450
C104	2-1706	Capacitor, silvered mica, 75 $\mu\mu$f, 500 V, 5%	Sangamo KR1475
C105 to C108		Same as C102	
C109 & C110	2-2141	Capacitor, silvered mica, 50 $\mu\mu$f, 500 V, 5%	Sangamo RR1450
C111 & C112	2-3527	Capacitor, silvered mica, 39 $\mu\mu$f, 5%	Sangamo KR1439
C113 to C116	2-2230	Capacitor, disc, ceramic, .01 μf	Erie 811-.01
C117		Same as C102	
C118		Same as C101	
C119	2-2554	Capacitor, silvered mica, 24 $\mu\mu$f, 500 V	Sangamo RR1424
CR101 & CR102	8-4182	Diode, selenium	General Electric 6RS1GH3TM1
I101 to I110	21-0624	Lamp, neon, wire leads, 1/25 W	General Electric NE-2
P101	17-1719	Plug, 11 pin	Amphenol 86-CP
V101 to V104	5-2362	Tube, 5963/7316	RCA/Amperex
XV101 to XV104	4-4508	Tube Socket, 9 pin, min.	Elco 274



NOTE:
RESISTERS:
WATTAGE ——— $\frac{1}{2}$ WATT UNLESS OTHERWISE NOTED.
TOLERANCE ——— ±5% UNLESS OTHERWISE NOTED.
CAPACITORS:
CAPACITY ——— IN μμf UNLESS OTHERWISE NOTED.
VOLTAGE RATING-500V UNLESS OTHERWISE NOTED.
TOLERANCE ——— 15% UNLESS OTHERWISE NOTED.
ALL VOLTAGES MEASURED WITH VTVM WITH COUNT AT "0".
AND PIN #10 DISCONNECTED.

SCHEMATIC DIAGRAM
MODEL 705AHJ
DECIMAL COUNTING UNIT

May 1959